TF 2416 Series

COUNTER/TIMER

INSTRUCTION MANUAL

MARCONI INSTRUMENTS

INSTRUCTION MANUAL
No. EB 2416

for

TF 2416 Series
COUNTER/TIMER

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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Chapter 1

General information

1.1. INTRODUCTION

The TF 2416 Counter/Timer provides comprehensive facilities for frequency and frequency ration measurement, period measurement by single or multi-period sampling, timing and general purpose counting.

Results are displayed by seven side-view neon indicator tubes; display storage is selectable.

The accuracy of all time dependent measurements is determined by the internal reference oscillator or by an external frequency source.

The TF 2416 is supplied fitted with a 10 MHz crystal oscillator, the TF 2416/1 is fitted with a temperature compensated oscillator and the TF 2416/2 with an oven-controlled oscillator.

Slope selector and a variable trigger level control with a low-pass filter facility are provided at the main signal input.

The main functions of the instrument are selectable by means of push-buttons. A nine-position range selector and a display time control are also provided. For the functions TIMING and COUNT, provision is made for the gating circuit to be operated by START and STOP push-buttons or control signals applied to rear-mounted sockets at which slope selectors are provided.

A standard frequency output (selectable at the range switch in decade steps from 0.1 Hz to 10 MHz) is obtainable at a rear-mounted socket. Two test frequencies, obtainable at the front panel, enable the basic operations of the instrument to be checked.

Data output is an optional facility that is fitted only if it is initially ordered. Two types of output are available; serial output (TF 2416/3) and parallel output (TF 2416/4).

Extensive use is made of integrated circuits: Schottky-clamped TTL for high speed gating, and MOS-LS1 for general counting and dividing functions.

Modular construction of the unit provides maximum accessibility of component parts for ease of servicing. All major functional assemblies including the front and rear panels, complete with their controls, plug into the main chassis. A fold away tilt-stand is attached to the ventilated wrap, and the four feet also provide for storage of the supply cable.

1.2. DATA SUMMARY

Frequency measurement
Multi-period measurement
Timing - single line or two line count

1.2.1 Functional Characteristics

FREQUENCY (Input A)		
	Maximum frequency	50 MHz
	Gating time	0.1 µsec to 10 sec in decade steps
	Accuracy	±1 count ± crystal stability

MULTI-PERIOD (Input A)

Maximum frequency	1 MHz
Gating time	1 to 10^7 periods in decade steps
Units of measurement	0.1 μsec
Accuracy	±0.1 μsec ± crystal stability

TIMING

Time units	0.1 μsec to 10 sec in decade steps
Control inputs -	
single line	Input A
two line	Start - input B Stop - input C or manual push button
Accuracy	±0.1 μsec -1 +0 time unit ± crystal stability

COUNT (Input A)

Maximum frequency	50 MHz
Control	Start - Input B Stop - Input C or manual push button

1.2.2 Input Characteristics

INPUT A

Frequency range	10 Hz to 50 MHz sinewave D.C. to 50 MHz pulse
Input selector	+ d.c. ; - d.c. ; a.c.
Input sensitivity	10 mV r.m.s. } on a.c. 15 mV peak pulse } 250 mV sinewave } on + (⊓) or 350 mV peak pulse } - (⊔)
Trigger slope	Negative on a.c. and - (⊔) Positive on + (⊓)
Trigger level	A.C. adjustable ±50 mV approximately. + (⊓) } adjustable ±1 volt - (⊔) } approximately
Frequency response	Response limited at maximum positive trigger level. Sensitivity falls off above 10 kHz at approximately 6 dB/octave
Paired pulse resolution	Typically better than 40 nsec (with pulse width 20 nsec and inter-pulse spacing 20 nsec).
Maximum input	250 volts r.m.s.
Input impedance	1 MΩ 30 pF approximately.
Input coupling	A.C.
Maximum d.c. level	400 volts
Controls	Trigger level/response 3 position slope/sensitivity selector

INPUTS B AND C

Frequency range	100 Hz to 5 MHz (sinewave at rated sensitiv D.C. to 5 MHz pulse Minimum pulse width 50 nsec
Sensitivity	500 mV r.m.s. sinewave 1 volt peak pulse
Maximum input	100 volts peak
Input impedance	20 kΩ 60 pF approximately
Input coupling	A.C.
Maximum d.c. level	250 volts
Trigger slope	Positive or negative
Controls	Slope selection. Manual switch.

Note - With the L.F. position of the TRIG LEVEL control selected, the input sensitivity is degraded by a factor of 3 (approx).

EXTERNAL REFERENCE	
Frequency range	100 Hz to 10 MHz (sinewave at rated sensitivit
Sensitivity	500 mV r.m.s. sinewave, 1 volt peak pulse
Maximum input	100 volts peak
Input impedance	20 kΩ 60 pF approximately
Input coupling	A.C.
Maximum d.c. level	250 volts
Trigger slope	Negative only

1.2.3 Internal Reference Characteristics

TF 2416	10 MHz crystal controlled
Ageing rate	$\pm 1 \times 10$ per month
Temp. coefficient at 23°C	$\pm 3 \times 10$ /°C typically
Maximum drift -10°C to +55°C	$\pm 5 \times 10$
TF 2416/1	10 MHz temperature compensated oscillator
Ageing rate	$\pm 1 \times 10$ per month
Temp. coefficient at 23°C	$\pm 1 \times 10$ /°C
Maximum drift 0°C to +50°C	$\pm 1 \times 10$
TF 2416/2	10 MHz oven controlled oscillator
Ageing rate	$\pm 1 \times 10$ per month
Temp. coefficient at 23°C	$\pm 1 \times 10$ /°C
Maximum drift -10°C to +55°C	$\pm 3 \times 10$

1.2.4 Display Characteristics

DISPLAY	7 digit display on side view numerical indicator tubes. Decimal point automatically positioned by function controls. Unit of measurement indicated by switch settings. Gate open indicator neon
DISPLAY STORAGE	Switch selected normal or stored
DISPLAY TIME	Adjustable 0.1 sec to 5 sec plus infinite

1.2.5 Outputs

TEST OUTPUTS	
10 MHz	Internal standard - 10 MHz squarewave to reference specification. External standard - squarewave as external reference frequency and specification.
1 MHz	Internal standard - 1 MHz squarewave to reference specification. External standard - squarewave as external reference frequency ÷10 and to external reference specification. Amplitude - 2.5 volts p-p minimum. Output Impedance - 1kΩ.

STANDARD FREQUENCY OUTPUTS	Output from divider chain as selected by gating time switch. Signal 2.5 V peak to peak minimum rectangul waveform.
DATA OUTPUTS	
TF 2416/3	Serial output 4-wire b.c.d 1-2-4-8 code ('1' ⩾+ 3.5 v '0' ⩽+ 0.5 v) 1-wire sequence start signal (Positive 12 pulse) 1-wire clock signal (Negative 12 v pulse) 1-wire print command (Negative 3.5 v edge)
TF 2516/4	Parallel output 4-wire per digit b.c.d 1-2-4-8 code ('1' ⩾+ 3.5 v ; '0' ⩽+ 0.5 v) 1-wire print command (Negative 3.5 v edge)

1.2.6 General

POWER SUPPLY	100-125 v/200-250 v 45-60 Hz/ 400 Hz			
WEIGHT & DIMENSIONS	Width	Height	Depth	Weight
	216 mm	89 mm	310 mm	4 kg
	8.5 in	3.5 in	12.0 in	8.8 lb

1.3. ACCESSORIES

Supplied	Instruction Manual
Optional	Rack Mounting kit type 54127-111

ALTERNATIVE MODELS

TF 2416/1	Temperature compensated oscillator
TF 2416/2	Oven controlled oscillator
TF 2416/3	Serial b.c.d output
TF 2416/4	Parallel b.d output
TF 2416/5	Temperature compensated oscillator with serial b.c.d output
TF 2416/6	Oven controlled oscillator with serial b.c.d output
TF 2416/7	Temperature compensated oscillator with parallel b.c.d output
TF 2416/8	Oven controlled oscillator with parallel b.c.d output

Chapter 2

Operation

2.1 INTRODUCTION

In order that the TF 2416 Counter/Timer may be used most effectively, the operation and capabilities of the instrument must be known. This chapter outlines installation, power supplies, control location and a brief explanation of the control function.

2.2 INSTALLATION

The TF 2416 can be used as a rack mounted instrument (with the rack mounting kit Type 54127-111) or a bench mounted version (supplied as standard). Normally set on four plastic feet, it can also be used in the tilted position by swinging the carrying handle forward and downwards, whilst applying a slight outward pressure to the handle sides, thus providing an additional front support.

2.3 POWER SUPPLY

Before connecting the mains supply to the instrument first check that the primary windings of the internal transformer are correctly connected for the supply voltage and that the appropriate rated fuse is fitted.

2.3.1 Mains Voltage Setting

To adjust setting, proceed as follows -

(i) Remove both sections of the instrument case by releasing the securing screws on both sides

(ii) Locate the transformer mounted at the rear of the instrument and note the primary tag connections facing the rear panel (see Fig.2.1).
The primary tags are accessible from the top of the instrument. If maximum access is required, remove the rear panel fixing screws (one in each corner of the panel) and unplug the entire rear panel assembly, complete with its surround, fron the rear of the instrument.

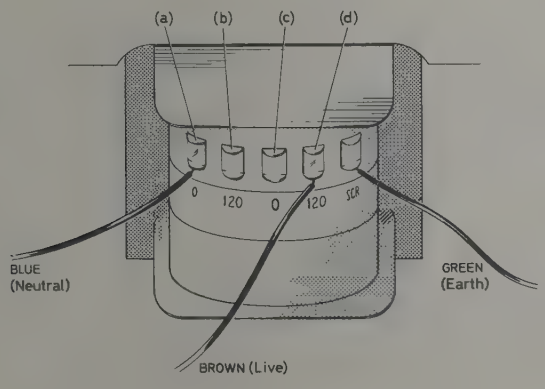


Fig. 2.1 Transformer tappings

200 - 250 V A.C. supply.

(iii) Link and solder the 120 V and 0 V tags located between the LIVE and NEUTRAL terminations (b and c). The primary windings are now series connected.

100 - 125 V A.C. supply.

(iv) Link and solder the two 0 V tags near the NEUTRAL terminations also link and solder the two 120 V tags near the LIVE termination (a and c, b and d). The primary windings are now parallel connected.

(v) Refit the rear panel assembly if removed ensuring that the rear-mounted power switch locates with the push-rod next to the transformer. Refit the instrument cover.

2.3.2 Mains Fuse Rating

The mains fuse is mounted above the cable entry at the rear of the instrument, check that it is suitable for the supply voltage as follows -

Supply Voltage	Fuse Rating	Marconi Part No.
100 - 125 V a.c.	600 mA slow blow	TF 2416/FPP/23402
200 - 250 V a.c.	300 mA slow blow	TF 2416/FPP/23401

2.3.3 Mains Lead Connection

A suitable mains supply plug must be fitted to the mains lead attached to the instrument. The three conductors are colour coded according to the International standards as follows -

Brown	-	LIVE
Blue	-	NEUTRAL
Green/Yellow	-	EARTH

2.4 CONTROLS AND CONNECTORS

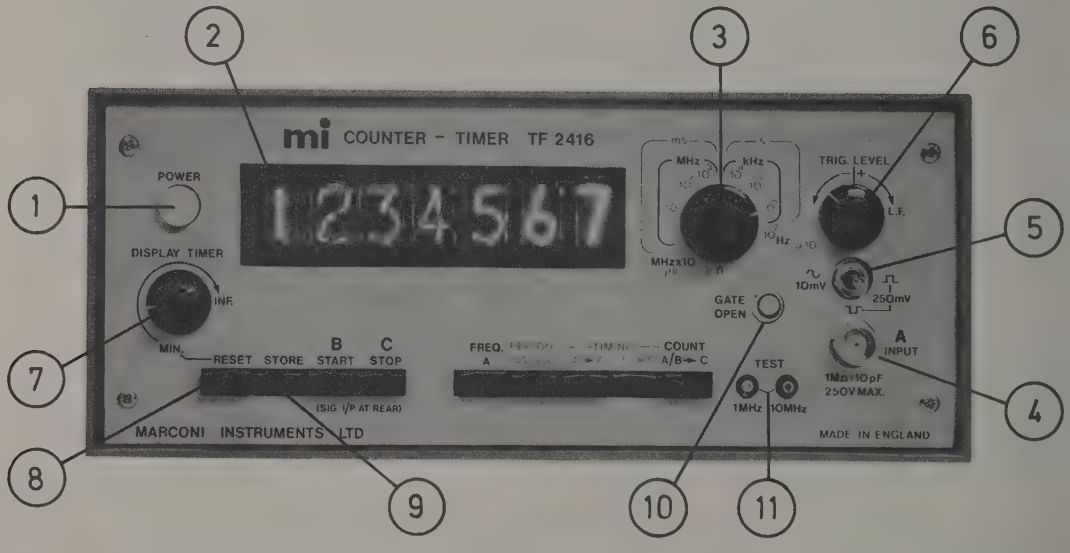


Fig. 2.2 Front Panel Controls & Connections

(1) POWER supply switch. Push button action. The indicator tubes will illuminate when supply is on.

(2) READOUT. 7 digit display. Decimal point automatically positioned by Range switch.
Readout will dim to indicate an invalid measurement e.g. when more than one function push button is depressed.

(3) RANGE switch. Selects appropriate range. Applies to all functions, except that the extreme anti-clockwise position of the switch is not for use on PERIOD function and if chosen in error the readout will dim.

(4) 'A' INPUT, SLOPE switch and TRIGGER LEVEL control. These controls apply only to signals received at the A INPUT socket.

The 3 position SLOPE switch selects the pulse-edge on which the instrument will trigger:-

(5) Right hand position - Positive going edge (250 mV sensitivity)
Centre position - Negative going edge (250 mV sensitivity)
(The TRIGGER LEVEL control is then turned in the appropriate direction until the instrument is triggered).

(6) Left hand position - Sinewave position
(Triggering occurs on the negative-going edge of the waveform. The setting of the TRIGGER LEVEL control then determines where the trigger level will be i.e. In the position region, at the zero or transitional point, or in the negative region of the waveform).
TRIGGER LEVEL LF position. As the Trigger Level control is turned fully-clockwise a ganged switch is operated to bring into circuit a low pass filter. This setting, which corresponds to the adjacent panel-legend L.F., is intended for low frequency inputs (up to approximately 10 kHz) whose waveforms are subject to aberration (caused by H.F. content).

(7) DISPLAY TIMER control. The setting of this control determines the time for which each result is displayed.

If the control is turned fully clockwise a ganged switch is operated. The control will indicate the panel legent INF (Infinite). The display is retained until the RESET push button is operated.

(8) RESET push button. Momentary depression of this control resets the instrument in readiness for a measurement.

If the STORE push-button is depressed when the RESET push-button is operated only the gating circuit and internal counters will be reset; the display will not change until a new measurement is shown at the end of the next gating period.

(9) STORE push-button. This push-button (and each of the five push-buttons in the FUNCTION bank beside the TEST sockets) will be automatically locked upon depression. It may be subsequently released by applying light momentary pressure.

When this push-button is in the released position (out) the indicator tubes display the progression and result of each count.

When the control is locked in the depressed position each count is displayed until the end of the next gating period, whereupon the new count is shown. On this setting, no visible change will occur in the display if the new count is the same as the previous result.

If count-overflow occurs when the push-button is 'out' the indicator on the extreme left may be seen to reset from 9 to 0, but when the store facility is used no such evidence of overflow is available for only the final result, which is held by the internal counters, is made visible. It is, therefore, advisable to determine the magnitude of a measurement before making use of the store facility.

FRONT PANEL (continued)

(10) GATE OPEN lamp. This neon lamp is illuminated for the duration of the gating period.

When the store facility is in use and consecutive measurements yield the same result, no change will occur in the display; however, the lamp serves to indicate that gating action is occuring and, therefore, that the prolonged display may be accepted as the current result.

Note. The lamp action will become less noticeable as very short gating times are selected.

(11) 1 MHz & 10 MHz TEST sockets. The outputs are available on all functions except TIMING. They are derived from the reference frequency source; the 10 MHz output directly, and the 1 MHz by way of a decade frequency divider.

Note. With the rear panel Standard switch to EXT the frequency of the 10 MHz output will be that of the external reference and the frequency of the 1 MHz output will be the external reference divided by 10.

The test outputs may be used to check the counting and readout operations of the instrument (see Chapter 2.5).

Note. Dimming of the display will occur if certain controls are incorrectly operated (see Chapter 4.3.4).

REAR PANEL

(12) STANDARD FREQUENCY Output socket. Provides an output from the (expand) divider chain as selected by the gating time switch.

(13) EXTERNAL Reference Frequency input socket.

(14) INT/EXT Frequency STANDARD selector switch. Enables either the internal oscillator (switch setting INT) or an external frequency source (switch setting EXT) to be selected as frequency source (switch setting EXT) to be selected as frequency standard for all time dependent measurements.

For the EXT setting signals from the external source should be applied to the coaxial socket below the STD switch.

Note. The five FUNCTION push-button switches and the START/STOP push-buttons on the front panel as well as the programmable START/STOP inputs and controls on the rear panel are explained in detail in the operating procedure (Chapter 2.6).

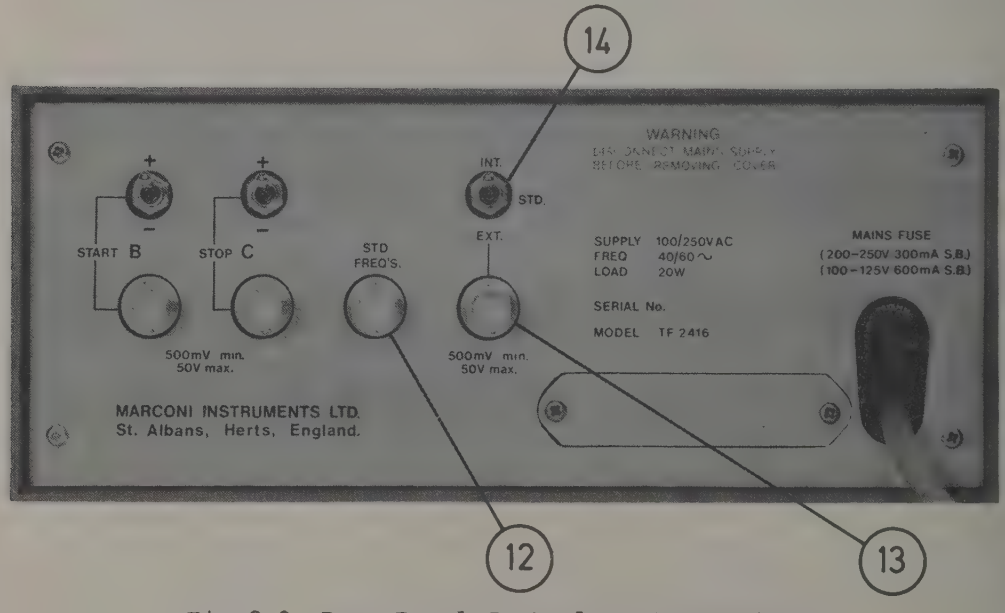


Fig.2.3 Rear Panel Controls & Connections

2.5 TEST FACILITY

The test outputs may be used to check the counting and readout operation of the instrument. To conduct the test proceed as follows -

(1) Establish the following control settings.

STD switch	set to:	INT
SLOPE switch	-	Centre (negative-going)
TRIG LEVEL	-	Mid-scale
DISPLAY TIMER	-	Mid-scale

(2) Connect the 10 MHz test output to the A-INPUT socket (use coaxial cable).

(3) Depress the FREQ push-button (the control should lock in the depressed position). Take a measurement on each position of the range switch (nine-position rotary) and compare each result with the corresponding displays given, under the appropriate heading, in TABLE 2.1.

(4) Connect the A-INPUT coaxial lead to the 1 MHz test socket. Repeat procedure (3) but for FREQ read PERIOD, and do not use the extreme anti-clockwise position of the range switch.

(5) Connect the A-INPUT coaxial lead to the 10 MHz test socket. Set the rear-mounted START-B and STOP-C switches to -ve. Using coaxial cable feed the 1 MHz test output to both the START-B and STOP-C rear-mounted sockets. Repeat procedure (3) but for FREQ read COUNT.
The result for COUNT should be 0000010 ± 1
This procedure may be repeated with the START-B and STOP-C switches set to +ve.

To check the operation of circuits acuated by the 'B' and 'C' push-buttons proceed as follows.

(6) Set the DISPLAY TIMER to INF.

(7) Depress the TIMING B→C push-button (the control should lock in the depressed position).

(8) Set the range switch to '1'.

(9) Momentarily depress the START-B push-button to initiate counting action. Observe the indicator on the extreme left; this should count repeatedly from 0 to 9, changing at the rate of one digit per second. Momentarily depress the STOP-C push button; counting should cease.

(10) Repeat procedure (9) for range switch settings 10 to 10^7, but the indicator that counts at the rate of one digit per second should be situated one position further to the right for each new setting.

RANGE SWITCH SETTING	DISPLAYS	
	FREQ	PERIOD
MHz x 10 ——	0000001 ±1	----
1 ——	0000010 ±1	000001.0 ±1
10 ——	000010.0 ±1	000010.0 ±1
10^2 ——	00010.00 ±1	000100.0 ±1
10^3 ——	0010.000 ±1	001000.0 ±1
10^4 ——	010000.0 ±1	010000.0 ±1
10^5 ——	10000.00 ±1	100000.0 ±1
10^6 ——	0000.000 ±1	000000.0 ±1
10^7 ——	000000.0 ±1	000000.0 ±1

TABLE 2.1 TEST FUNCTION DISPLAYS

2.6. OPERATING PROCEDURE

Measurements may be taken immediately after the supply has been switched on; however, for the accuracy of results to conform to the specification a period of at least fifteen minutes (for temperature stabilization of the internal reference oscillator circuit) should elapse before a measurement is taken.

No warm-up period is necessary for COUNT function or when an external standard frequency is used as reference source; in both circumstances the internal oscillator is unused.

2.7. FREQUENCY MEASUREMENT

2.7.1. Principle of Operation

In this function the setting of the rotary range switch determines which of nine signal frequencies, derived from the standard frequency reference source, will control the internal gate; its setting therefore determines the gating time.

For the duration of the gating time, cycles of the A-INPUT frequency pass through the gate to a chain of counter/indicator-drive circuits. The indicators display the resultant count; where appropriate a decimal point is included in the display so that the readout is shown in Hertz (Hz), kilo-Hertz (kHz) or mega-Hertz (MHz). Counts displayed on the highest range (MHz x 10) should be multiplied by ten for the result to be in mega-Hertz; thus, for example, the display 0000001 should be read as 10 MHz.

2.7.2. Measurement Procedure

(1) Set the rear-mounted STD switch to INT if the internal oscillator is to function as reference source; if an external reference source is to be used, set the switch to EXT and refer to Chapter 2.4 (12).

(2) If a data logging output facility is to be used refer to Chapter 2.13.

(3) Set the DISPLAY TIMER and STORE push-button as required (for control function refer to Chapter 2.4 (7) and Chapter 3.4 (9)).

(4) Apply the input signal to the coaxial A-INPUT socket and set the adjacent slope switch to the required position (for control function refer to Chapter 2.4 (4)).

(5) Depress the FREQ push-button.

(6) Set the range switch to a gating time for which the result will lie within the count capacity of the instrument. (When the order of the input frequency is unknown the shortest gating time may be used first and the measurement then repeated on progressively lower ranges until the value is suitably resolved). The gating times for the range switch positions, in clockwise order, are listed below: the units of measurement for the various positions on frequency function are marked in black on the front panel.

Range Switch Position	Time
1 (MHz x 10)	0.1 µs
2 (MHz)	1 µs
3 "	10 µs
4 "	100 µs
5 "	1 ms
6 (kHz)	10 ms
7 "	100 ms
8 "	1 s
9 (Hz)	10 s

TABLE 2.2 GATING TIMES

(7) If the DISPLAY TIMER is set to INF momentarily depress the RESET push-button.

(8) Adjust the setting of the TRIGGER LEVEL control to suit the input waveform (for control use refer to Chapter 2.4 (5)). After a brief counting period the result of the measurement should be displayed.

2.8. PERIOD/MULTI-PERIOD MEASUREMENT

Note. On PERIOD function, single period measurement is catered for by position '1' of the range switch (for which the count is recorded in 0.1 μs units). Single period measurement may be taken also on function TIMING A→A for which the time unit is selectable: refer to Chapter 2.9.2.

2.8.1. Principle of Operation

In this function signals applied to the A-INPUT control the internal gate. The gate is held open for 'n' periods of the input waveform, where 'n' is the setting (for example 10^2) of the range switch. Throughout the gating time pulses derived from the standard frequency reference source, which occur at a rate of ten per microsecond, pass through the gate to a chain of counter/indicator-drive circuits. The resultant readout is the time (in 0.1 μs units) for which the gate was held open and is a period or multi-period measurement (according to the range switch setting) of the input waveform. A decimal point is included in the display so that the readout is in microsecond units.

2.8.2. Measurement Procedure

(1) Carry out procedures (1), (2), (3) and (4) of Chapter 2.7.2.

(2) Depress the PERIOD push-button.

(3) Set the range switch to the number of periods (n) over which the measurement is to be taken; initially this number should be such that the result will lie within the count capacity of the instrument. (When the order of the input frequency is unknown a single period measurement may be taken initially, and the measurement then repeated over a progressively larger number of periods until the value is suitably resolved).
The value of 'n' are marked in blue around the range switch.
The extreme anti-clockwise position of the switch is not for use on PERIOD function.

(4) If the DISPLAY TIMER is set to INF momentarily depress the RESET push-button.

(5) Adjust the setting of the TRIGGER LEVEL control to suit the input waveform (for control use refer to Chapter 2.4 (5)). After a brief counting period the result of the measurement should be displayed.

To obtain the time corresponding to a single period of the input waveform, the readout should be divided by the value of 'n' to which the range switch is set.

Measurement Example:-

Consider as input frequency in the order of 100 kHz whose period is 10.2345678μs. If a measurement were taken first on the range n = 1 the resultant display would be 000010.2μs*. If the range n = 10^6 were then used, the count capacity would be exceeded ten times during the measurement and the resultant readout would be 234567.8μs*. Because this readout was obtained over 10^6 periods of the input waveform it should be divided by 10^6 to provide the value 0.2345678μs for one period. The first two digits determined on the first range (but occurring as overflow digits on the range 10^6) should then be appended to give 10.2345678μs as the period of the input signal.
* The display accuracy is specified in Chapter 1.2.4.

2.9. TIMING

2.9.1. Principle of Operation

Two modes of gating are available on TIMING function.

On TIMING A→A the gate is opened by the first pulse received at the A-INPUT socket and closed by the second pulse.

On TIMING B→C the gate is opened by a signal received at the B-INPUT or by depression of the START push-button; it is closed by a signal received at the C-INPUT or by depression of the STOP push-button.

Throughout the gating time, pulses derived from the standard frequency reference source pass through the gate (at a rate of ten pulses per microsecond) and through a frequency divider chain to counter/indicator-drive circuits. The range switch setting determines the effective division factor of the frequency divider chain and, therefore, the time unit of the count. Where appropriate, a decimal point is included in the display so that the readout is in microseconds, milliseconds or seconds according to the setting of the range switch.

Results displayed on the highest range (s x 10) should be multiplied by ten for the measurement to be in seconds; thus, for example, the display 0000001 should be read as 10 seconds.

2.9.2. Measurement Procedure

(1) Carry out procedures (1), (2) and (3) of Chapter 2.7.2.

(2) Set the range switch for the required time unit. For clockwise rotation of the range switch the time units are 0.1 µs to 10s in decade steps (as listed in Table 2.2).

(3) Carry out the procedures given below under the timing mode to be used.

'TIMING A→A'

(a) Apply the input signal to the A-INPUT socket and set the adjacent slope switch to the required position (for control function refer to Chapter 2.4 (5)).

(b) Depress the TIMING A→A push-button.

(c) Adjust the setting of the TRIGGER LEVEL control to suit the input waveform (for control use refer to Chapter 2.4 (6)).

If the DISPLAY TIMER is set to INF momentarily depress the RESET push-button to enable the A-INPUT signals to initiate a measurement. For other settings of this control measurements should occur automatically.

(a) Note. Gating may be started and stopped manually by the appropriate push-buttons or electronically by signals applied to the START-B and STOP-C sockets; alternatively the gate may be opened by one method and closed by the other.
The sockets may be connected in parallel if single line gate control is required; then, the first of two successive signals on the line will open the gate and the second will close it.
External leads to these START-B and STOP-C sockets should be as short as practicable and screened to minimise pick-up which might otherwise cause unwanted trigger operation. It is recommended that, where practicable, external trigger circuits for these inputs be battery powered to eliminate the possibility of the instrument being triggered by spurious mains-initiated pulses or ripple.

Connect a coaxial signal-cable to each rear-mounted socket (START-B: STOP-C) that is to be used for gate control.

(b) Momentarily depress the RESET push-button.

(c) Timing will commence when the B-START push-button is momentarily depressed (or a signal is applied to the START-B socket) and will cease when the C-STOP push-button is momentarily depressed (or a signal is applied to the STOP-C socket).

* See note below.

2.10. COUNT

2.10.1. Principle of Operation

On this function gating may be started and stopped manually by depression of the B-START and C-STOP push-buttons, or electronically by signals applied to the START-B and STOP-C sockets; alternatively the gate may be opened by one method and closed by the other.

Throughout the gating time signals received at the A-INPUT socket pass through the gate to a chain of counter/indicator-drive circuits. The readout is therefore the number of A-INPUT signals received during the gating time.

2.10.2. Measurement Procedure

(1) Carry out procedures (2), (3) and (4) of Chapter 2.7.2.

(2) Connect a coaxial signal cable to each rear-mounted socket (START-B: STOP-C) that is to be used for gate control.

(3) Depress the COUNT push-button.

(4) Momentarily depress the RESET push-button.

(5) Set the TRIGGER LEVEL control to suit the input waveform (for control use refer to Chapter 2.4 (6)).

(6) To begin the gating period momentarily depress the B-START push-button or apply a signal to the START-B socket.

(7) To end the gating period momentarily depress the C-STOP push-button or apply a signal to the STOP-C socket.

* See note below.

* Note. The shaper circuits of B and C inputs are designed for low frequency sinusidal signals down to 100 Hz. To operate from squarewave signals of less than 1 kHz, it may be necessary to connect a 900pF (approx.) capacitor in series with to B and/or C inputs to differentitate the signal.

2.11 STANDARD FREQUENCY OUTPUT FACILITY

Standard frequency signals are available at the rear-mounted coaxial STD FREQ socket on functions FREQUENCY and COUNT. The signals are also available on both TIMING functions but only throughout the period that the gate is held open. The signals are not available on PERIOD function.

The output signal frequency is dependent upon the setting of the range switch as indicated in the table below.

The source of the signals is determined by the setting of the STD switch (refer to Chapter 2.4 (13)). Signals are derived from the reference source by decade frequency division; therefore, when an external reference standard is used its frequency should be 10 MHz (otherwise the table below will not be valid). Note. The signals are momentarily interrupted whenever reset action occurs.

Range Switch Positions (clockwise order)	Standard Frequency Output
1	10 MHz
2	1 "
3	100 kHz
4	10 "
5	1 "
6	100 Hz
7	10 "
8	1 "
9	0.1 "

TABLE 2.3 STANDARD FREQUENCY OUTPUT

2.12 EXTERNAL REFERENCE FACILITY

When the rear-mounted switch marked STD is set to INT the internal 10 MHz oscillator is employed as reference frequency source.

When the STD switch is set to EXT the internal oscillator is switched out of circuit and signals, from an external source, applied to the EXT socket serve as reference signals for the instrument.

The external reference facility may be used to increase the accuracy of the instrument for the standard functions (by use of an external 10 MHz source frequency the accuracy of which is superior to that of the internal oscillator; refer to Chapter 1.2.3) or to alter the significance of the readout so that the instrument may be operated in a non-standard manner (by use of an external source frequency other than 10 MHz).

The facility may be used for frequency ratio measurement; the subject is treated in the following section.

2.12.1 Frequency Ratio Measurement

To conduct a frequency ratio measurement for signals from two sources proceed as follows.

(1) Set the rear-mounted STD switch to EXT.

(2) Apply signals (f_S) from one source to the STD socket.

(3) Apply signals (f_A) from the second source to the A INPUT socket and set the adjacent slope switch to the required position (for control function refer to Chapter 2.4 (5)).

(4) If a data logging output facility is to be used refer to Chapter 2.13.

(5) Set the DISPLAY TIMER and STORE push-button as required (for control functions refer to Chapter 2.4 (7) and Chapter 2.4 (9).

(6) The measurement may be conducted on FREQUENCY or PERIOD function; the two functions are treated separately below.

(a) Frequency Function

When the FREQ A push-button is depressed, signals (of frequency f_S) applied to the 'STD' socket pass by way of a frequency divider chain to the gate control circuit. The gate is held open while a number of pulses, equal to the division factor of the chain, is received at the 'STD' socket; the division factor is indicated by the setting of the range switch (blue scale: 1 to 10^7 in decade steps).

Throughout the gating period, signals (of frequency f_A) applied to the 'A INPUT' socket pass through the gate to the counter/indicator-drive circuits.

$$\text{The Displayed Count} = \frac{f_A}{f_S} \times \text{Division Factor}$$

The ratio $f_S : f_A$ is therefore given by:

$$\frac{\text{Division Factor}}{\text{Count}} : 1$$

Example

With the FREQ A push-button depressed, the range switch set to 10^4, f_S = 80 kHz, f_A = 20 kHz and a displayed count of 2500 the ratio f_S to F_A would be given by:

$$\frac{10^4}{2500} : 1$$

$$4 : 1$$

(b) Period Function

While the PERIOD push-button is depressed the gate is controlled by signals (of frequency f_A) applied at the A INPUT socket. These signals pass by way of a frequency divider chain to the gate control circuit; the gate is held open while a number of pulses, equal to the division factor of the chain, is received at the A INPUT socket. The division factor is indicated by the setting of the range switch (blue scale: 1 to 10^7 in decade steps).

Throughout the gating time, signals (of frequency f_S) applied to the STD socket pass through the gate to the counter/indicator drive circuits.

$$\text{The Displayed Count} = \frac{f_s}{f_A} \times \text{Division Factor}$$

The ratio $f_s : f_A$ is therefore given by:

$$\frac{\text{Count}}{\text{Division Factor}} : 1$$

Example

With the 'PERIOD' push-button depressed, the range switch set to 10^3, f_S = 80 kHz, f_A = 20 kHz and a displayed count of 4000 the ratio f_S to f_A would be given by:

$$\frac{4000}{10^3} : 1$$

$$4 : 1$$

Note. For either function 'a' or 'b' above, the range switch setting should be such that the count capacity is not exceeded. For maximum accuracy the displayed count should be the highest obtainable without exceeding the count capacity.

(7) Momentarily depress the RESET push-button.

(8) Adjust the setting of the TRIGGER LEVEL control to suit the signal waveform applied at the A INPUT socket (for control use refer to Chapter 2.4 (6)).

2.13. DATA LOGGING OUTPUT FACILITY

This facility is an optional extra that is provided only if specifically requested when the instrument is ordered. For this facility either of two options may be ordered: TF2416/3 Serial output or TF2416/4 Parallel output. The particular form of output provided is denoted by the corresponding suffix /3 or /4 which is added to the instrument type reference on the front and rear panel.

The data is available at the Amphenol 36-pin socket mounted on the rear panel. Each digit is presented in b.c.d 1-2-4-8 code (for signal specification refer to Chapter 1.2.5).

NOTE. The data outputs are obtained from the count-storage circuits; therefore, with the STORE push-button depressed the recording time of data logging equipment may be extended up to the end of the subsequent gating period. When the STORE push-button is in the released condition the recording time must not exceed the minimum display time of the instrument; this restriction ensures that data logging will be completed before the instrument is reset.

Connections at the output socket are as follows.

TF2416/3 - Serial output

Pin	Function
1	BCD 1
2	BCD 2
3	BCD 4
4	BCD 8
5	Clock Signal
10	Sequence Start Signal
35	Print/Punch Command O/P
36	Chassis-earth

Other pins unused

TF2416/4 - Parallel output

Pin No.	Function
1	MSD Line 1
2	MSD Line 2
3	MSD Line 4
4	MSD Line 8
5	Unused
6	2nd MSD Line 1
7	2nd MSD Line 2
8	2nd MSD Line 4
9	2nd MSD Line 8
10	Unused
11	3rd MSD Line 1
12	3rd MSD Line 2
13	3rd MSD Line 4
14	3rd MSD Line 8
15	Unused
16	4th MSD Line 1
17	4th MSD Line 2
18	4th MSD Line 4

Pin No.	Function
19	4th MSD Line 8
20	Unused
21	5th MSD Line 1
22	5th MSD Line 2
23	5th MSD Line 4
24	5th MSD Line 8
25	Unused
26	6th SD Line 1
27	6th SD Line 2
28	6th SD Line 4
29	6th SD Line 8
30	Unused
31	LSD Line 1
32	LSD Line 2
33	LSD Line 4
34	LSD Line 8
35	Print/Punch Command O/P
36	Chassis-earth

NOTE MSD = Most significant digit

LSD = Least significant digit

Chapter 3

Technical description

3.1 INTRODUCTION

The circuit of the TF 2416 Counter/Timer is covered primarily by two main diagrams: a Block Schematic diagram (E69/26) showing the general system by which function selection is controlled within the instrument, and a Signal Path Diagram (E69/25) showing the various signal lines inter-connecting the plug-in cards. Separate circuit diagrams are provided for the individual plug-in cards and sub assemblies; these are treated as and when appropriate throughout the circuit description.

Certain plug-in cards include multi-element integrated circuits. On circuit diagrams certain elements are depicted as D-shaped symbols containing the component reference of the particular integrated circuit to which they belong. Within this circuit description such elements are distinguished from others of the same integrated circuit by means of their output connection numbers which appear bracketed and as suffixes to the component reference of the 'parent' integrated circuit. Diagram E69/01 will be used to exemplify this nomenclature: two integrated circuits appear near the centre of the diagram, that to the left would be referred to as X1(6) and that to the right as X1(8).

3.2 POWER SUPPLY

Diagram E68/93 shows the circuit of the rear-panel-mounted components.

The input connections of the supply cable are depicted by the points L (live), N (neutral) and E (chassis-earth). The supply passes via the double-pole push-button-operated POWER switch S1, fuse FS1 and the suppressor circuit comprising L1,2/C1 a-c. This circuit arrangement is again depicted on diagram E69/25; the supply is applied to the POWER SUPPLY UNIT type 77/220, the full circuit of which is shown on diagram E68/92.

The mains supply is received at transformer T1, the primary winding of which should have been appropriately linked to suit the supply voltage: series connected for 200-250 V a.c. or parallel connected for 100-125 V a.c.*

Three low tension stabilized supplies are produced by the power unit:

(i) +5 V** available at pin 9 and derived via full-wave rectifying diodes D3,4 and integrated circuit X2.

(ii) +13 V ** available at pin 6, preset by control R2 and derived via D2, 5 and X1.

(iii) -16 V ** available at pin 7, preset by R3 and derived via D7,8 and X3.

* For transformer connection refer to Chapter 2.3.1.

** With respect to chassis-earth; for voltage tolerance refer to Chapter 4.3.1

One unstabilized high tension supply of +240 V ** is produced by the unit. This supply is available at pin 1; it is derived via full-wave rectifying diodes D1,6 and smoothed by the action of C1.

The common line of the four supplies (0 V : chassis-earth) is connected to pin A.

The five output lines of the power unit are represented on diagram E69/25, but the individual connections of these supply lines to the various modules or sub-circuits of the instrument are indicated on diagram E69/26.

3.3 FUNCTION SELECTION CIRCUIT

The instrument employs a number of signal gates that are housed by various plug-in cards and are opened (enabled) or closed (inhibited) in different combinations according to the function that is to be performed.

Whether a gate is enabled or inhibited is determined by the potential applied to its control input/s.

The arrangement of control lines of the plug-in cards is shown on diagram E69/26. The control lines stem from the SWITCH BOARD ASSEMBLY AND FRONT PANEL circuit type 77/010, which is shown in full on diagram E68/91.

On this diagram E68/91 the function selector push-buttons appear as switches S7(A-D) to S11(A-D) and are shown in the 'rest' or 'out' positions.

When FREQUENCY function is selected the 4-pole switch S7(A-D) changes state so that the +13 V potential (received at termination 3) is applied to the control lines connected to terminations R, N and T. The potential is also applied to the rotor of RANGE switch wafer S1C; on certain settings of the switch it serves to actuate the appropriate decimal point in the display by way of termination 21, 22 or 24. The rotors of wafers S1A and S1B are strapped to the +13 V supply line: S1A controls frequency division within the instrument, and S1B controls divider transfer action within the circuit of the oscillator card.

Similar action occurs when each of the remaining function selector push-buttons are separately depressed to establish the particular gating combination appropriate to the required function.

The circuit of TR1, which includes R(2-6),13 and 14 as current weighting resistors, serves to detect whether more than one function selector push-button is depressed at any one time or whether position 1 of RANGE switch S1 is selected on PERIOD function.

For either eventuality a positive-going potential change is produced at termination 18: by cut-off of TR1-collector current and conduction by D2 (when more than one function selector push-button is depressed) or by Termination of R13 and R14 to the +13 V supply line for cut-off of D2 diode current and over-ride of T1 (when RANGE switch position 1 is selected on PERIOD function). The potential change serves to trigger the scan alarm circuit by way of card type 77/807 so that the display is dimmed to indicate an incorrect setting of the controls.

The complement of the main gating waveform (represented thus: $\overline{\text{GATE CONTROL}}$ O/P) is received at termination 11 and operates the circuit of TR2 and neon lamp LP1: when the gate is open TR2 collector current is cut-off and LP1 is illuminated until, at the end of the gating period, TR2 again conducts.

The lines from terminations 15 and 16 convey the 10 MHz and 1 MHz test outputs of cards types 77/500 and 77/400 to output sockets SK1 and SK2.

** With respect to chassis-earth; for voltage tolerance refer to Chapter 4.3.1

A monostable circuit, which determines the time for which displays are retained, is carried by card type 77/600 and is connected by way of termination F to the DISPLAY TIME ganged controls R19 and S2. When switch S2 is closed R19-slider is connected to the 0 V line (at termination 2): the setting of R19 then determines the monostable period and, therefore, the display time. When S2 is open R19-slider is connected to the mid-point of potential divider R1/R12; for this condition the monostable is held inoperative and each display is retained until reset action is initiated by momentary depression of RESET push-button S3.

Depression of S3 connects the reset line of card type 77/600 (received at termination H) to the 0 V line (received at termination 2). Similarly when the STORE push-button is depressed the STORE control line of card type 77/400 (received at termination M) is connected to the 0 V line.

For functions 'TIMING B → C' and 'COUNT A/B → C' the +2 V line is connected, by way of S10B and S11B, to termination L (for application to card type 77/320 control input 13) and to the rotors of START and STOP switches S5 and S6. Depression of S5 applies the +13 V potential to the START control line of card type 77/600, and depression of S6 applies the +13 V potential to the STOP control line of the same card.

3.4. PRE-AMPLIFIER TYPE 77/300 (Drg. E68/95)

The 'A INPUT' socket shown on diagram E95/25 is socket SK1 of the Pre-Amplifier circuit shown on diagram E68/95.

Signals received at the socket pass to the input network in which C1 acts as coupling capacitor and R5/C4 provide compensated ballast for clipping diodes D1 and D2.

When the SLOPE switch S2(A,B) is set to either of the pulse positions (+ve or -ve) components C12/R6,21 combine with R5 and C4 to form an input attenuator; the attenuation factor of which is approximately 5.

When the TRIGGER LEVEL control is turned fully clockwise its ganged switch S1 brings C5 into circuit to establish low pass filter action.

The clipping diodes D1 and S2 serve to confine the amplitude of signals, passed to the gate of a.c. - coupled transistor TR1, to within $\pm$1 V.

A trigger level control voltage for the gate circuit of TR1 is derived from the +13 V supply by the potential divider comprising R2 and preset potentiometer R1.

At junction R7-C7 the trigger level control voltage combines with feedback, received at termination 6, from the subsequent Pulse Shaper card. The trigger level control circuit is such that movement of R1-slider from mid-position to either end of its track cause the d.c. output level of the pre-amplifier, at termination 3, to change by approximately $\pm$1 V.

The pre-amplifier comprises TR1 as source follower and TR2/TR3 arranged as a two-stage compound negative feedback amplifier. The d.c. gain of the pre-amplifier is set to approximately 10 by means of R14,R15 and R17. The overall gain for either pulse input setting of 52 is approximately 1.5.

On the sinewave position of the SLOPE switch series connected components R16-C10 are switched in parallel with R14 by S2A; the pre-amplifier overall a.c. - gain is then approximately 25.

Section S2B of the SLOPE switch controls the slope selection circuits of the 'PULSE SHAPER' plug-in card type 77/310.

3.5. PULSE SHAPER TYPE 77/310 (Drg. E68/94)

FEEDBACK AMPLIFIER

Output signals of the PRE-AMPLIFIER type 77/300 are received at termination 16.

The circuit of TR1 functions as d.c. bias feedback amplifier and employs R1/C1 and R5/C2,3 as signal integrators; its output passes via termination 15 to the pre-amplifier (termination 6) described in Chapter 3.4. The feedback voltage from the amplifier is adjustable by means of R2, the setting of which is treated in Chapter 4.3.2.

SHAPER CIRCUIT:

Signals received at termination 16 feed the circuit of p-n-p transistor TR2 which serves as input buffer/emitter follower and temperature compensates the base circuit of TR3 for stability of the pulse shaper trigger level threshold.

The pulse shaper consists primarily of TR3/TR4 in a configuration similar to that of a Schmitt trigger circuit but with the two transistors directly coupled for high speed operation. Diode D3 permits the collector voltage of TR3 to swing positive by approximately 1.5 V without attenuation of TR3 emitter current. The low value of common emitter resistor R12 enables the threshold differential of the trigger circuit to lie within the range approximately 300 to 400 mV.

The pulse shaper output from TR4-collector drives emitter follower TR5 which acts as buffer and interfacer for the subsequent slope selection circuit.

SLOPE SELECTION CIRCUIT

This circuit consists essentially of integrated circuit X1 which comprises four two-input NAND-gates. The NAND-gates X1(6)* and X1(11) are employed in twin circuits each with a control input (terminations 14 and 13); NAND-gate X1(11) receives the output of TR5 directly, while the other receives it by way of inverter X1(3). The twin NAND-gate circuits feed X1(8) at whose output either 'true' or 'false' signals, derived from TR5, are produced. The 'true' output occurs while termination 14 is connected to chassis-earth; the 'false' output occurs when termination 13 is connected to chassis-earth. The connection to chassis-earth of the appropriate control termination is performed by switch section S2B of the pre-amplifier circuit referred to in Chapter 3.5.

Output signals of NAND-gate X1(8) feed the circuit of TR6/TR7 which forms a low frequency output stage for signals derived from the shaper circuit and used on functions PERIOD and TIMING. Throughout the instrument resetting period TR7 is held cut-off to inhibit the production of output signals at termination 6.

Output signals of NAND-gate X1(8) also feed the gating circuit of quadruple NAND-gate integrated circuit X2. The signals are received at X2(3) input 1 but this NAND-gate together with X2(11) are enabled, by means of control input termination 8, only for the functions FREQUENCY and COUNT A/B→C. When either function is used termination 10 is held at approximately +5 V so that X2(8) is 'enabled' to permit signals, received at termination 7, to pass to X2(6) input 5 where the serve to gate the output of X2(3).

For functions PERIOD and TIMING, termination 8 is held at 0 V to 'inhibit' X2(3) and X2(11) whose outputs for this condition hold X2(6) and X2(8) 'enabled'; therefore, signals received at termination 10 pass via X2(8) and X2(6) to gated output termination 5.

The various signal lines to and from the pulse shaper card are represented on SIGNAL PATH DIAGRAM E69/25.

* For nomenclature refer to Chapter 3.1

3.6 OSCILLATOR AND DECADE DIVIDER TYPE 77/510 & 77/511 (Drg. E69/22)

Reference signals for the various time dependent measurements conducted by the instrument are produced by the plug-in OSCILLATOR AND DIVIDER card. Within the standard instrument this card is type 77/500; for the TF 2416/2 it is replaced by card type 77/510 whilst for the TF 2416/1 it is replaced by card type 77/511.

Chapter 3.6.1 is applicable to the standard instrument; Chapter 3.6.2 is applicable to instruments carrying either of the two options.

3.6.1 Oscillator and Divider Type 77/500 (Drg. E69/02)

OSCILLATOR AND EXTERNAL INPUT CIRCUIT

The oscillator section of this card contains transistors TR3 and TR4 which are connected to form a crystal control oscillator.

Transistor TR3, operating in common base mode, drives emitter follower TR4. Feedback to the circuit of crystal XL1 is obtained from the split emitter load R23/R24 of TR4. The frequency of oscillation is preset to 10 MHz by trimmer capacitor C8, adjustment of which is treated in Chapter 4.3.3.*

The oscillator output from TR4-collector feeds input 9 of integrated circuit X3(8)* by way of the interfacing circuit D7/R25. The integrated circuit comprises a Schmitt trigger stage which functions as shapter for the oscillator output; however, the stage is held inoperative while termination N is connected to chassis-earth which is the condition established when the STD switch is set to the EXT (external) position, as shown on SIGNAL PATH DIAGRAM E69/25.

Signals received at the STD external reference input socket (SK4 on diagram E69/25) are accepted at termination 11 of the card (diagram E69/02). The signals pass to the a.c. - coupled common emitter amplifier TR2 for which D6 functions as clipping diode for negative excursions of the waveform; positive excursion clipping is provided by the TR2 base-emitter junction and capacitors C4/C5.

The collector output of TR2 feeds input 5 of integrated circuit Schmitt-trigger/pulse-shaper stage X3(6). This stage is held inoperative while termination P is connected to chassis-earth; the condition established when the STD switch is set to INT.

The outputs of pulse shapers X3(8) and X3(6) feed NAND-gate X4(3). The setting of the STD switch determines which pulse shaper shall be operative and which inoperative; it thus determines from which source (internal or external) the reference signals shall be derived. The output potential of the inoperative shaper is such as to hold X4(3) 'enabled' for the passage of the required signals.

Output signals of X4(3) feed the 10 MHz test socket of the instrument by way of R31 and termination R; they also feed input 4 of NAND-gate X4(6) and, while this stage is 'enabled' by the control potential at termination 16, pass via inverter/NAND-gate X4(8) to the oscillator (internal or external) output termination T.

Throughout the resetting period of the instrument the control potential at termination 16 is such as to inhibit X4(6) so that no reference signal pulses occur at termination T until reset action has been completed.

* NOTE When an integrated circuit element is a Schmitt trigger stage the letters 'ST' appear inside the symbol and the integrated circuit reference number appears outside.

DIVIDER CIRCUIT

The divider circuit comprises the large scale integrated circuits X1 and X2 and their associated components.

Each integrated circuit contains two pairs of cascade-connected decades (The first pair: input 4, output 8. The second pair: input 14, output 9). The four pairs are linked, as shown on diagram E69/02, to form a chain of eight cascade-connected decades. The chain is fed by signals received at termination 7.

By means of the potentials on control lines at terminations L,M,9,10 and 6 any one of the decades may be selected to supply its output, via connection 2 and inverted/amplifier TR1, to termination J. Each control line is either connected to the +13 V supply line or left in the open circuit state by the rotary RANGE switch S1(A-D) of diagram E68/91 treated in Chapter 3.3.

Decade reset action is controlled by the circuit containing diodes D1-5. A positive-going reset pulse received at termination H resets each decade to the nine state when diode gate D1/D2 is 'enabled' by a 13 V potential at termination E, or to the zero state when diode gate D3/D4 is 'enabled' by a 13 V potential at termination F.

The circuit of TR5 serves to hold connection 5 of X1 and X2 at approximately 0 V for part of the reset period; a condition necessary to achieve fast reset action of the decade chain.

3.6.2 Oscillator and Divider Types 77/510 & 77/511 (Drg. E69/22)

The circuit shown on diagram E69/22 covers cards type 77/510 and 77/511 and, with the exception of the oscillator stage feeding input 9 of integrated circuit X3, is identical to the circuit of card type 77/500 described in Chapter 3.6.1.

Two oscillator stages enclosed by chain lines and marked 'A' and 'B' appear on diagram E69/22. Only one of these stages is included in the circuit: stage 'A' for card type 77/511, stage 'B' for card type 77/510.

Stage 'A' is the temperature compensated 10 MHz sinewave crystal oscillator (card type 77/511: TF 2416/1 *) Stage 'B' is the oven controlled 10 MHz sinewave crystal oscillator (card type 77/510: TF 2416/2 *) for which the oven supply is received by way of connectors SK2 and PL2.

Both oscillator stages incorporate a trimmer capacitor, adjustment of which is treated in Chapter 4.3.3.

3.7 DIVIDER INTERFACE TYPE 77/400 (Drg. E68/100)

This plug-in card houses several signal level interfacing circuits for interconnection of a number of circuit sections of the instrument; it also carries several subsidiary gating circuits which enable the passage of some signals to be inhibited for certain functions of the instrument.

Pulses produced at output termination T of the OSCILLATOR AND DIVIDER card (and derived from the 10 MHz internal oscillator or from an external reference source) are received at termination T (drg.E68/100). These signals take two routes:

(i) They pass by way of X1(11) when this NAND-gate is 'enabled' on functions FREQUENCY and COUNT (by means of control termination M) or PERIOD (by means of control termination K). For each of these three functions the signals feed input 2 of X3(3): on other functions the output level of X1(11) holds X3(3) 'enabled'.

* Refer to Chapter 1.2.3.

(ii) They are inverted by X1(3) and, while X1(6) is 'enabled' by control termination 15, pass to input 9 of X1(8). NAND-gate X1(8) is 'enabled' on both TIMING functions, by control termination L, so that the signals feed input 1 of X3(3): on other functions the output level of X1(8) holds X3(3) 'enabled'.

Output pulses of X3(3) drive integrated circuit decade X2 for which reset signals are received at termination N. Output pulses of the decade which occur at one tenth of the input pulse rate, feed the 1 MHz test socket of the instrument by way of inverted X3(6).

By means of control termination L and M the base of the TR6 is biased positive for all functions except PERIOD to allow the output pulses of decade X2 to operate TR6 for the production of corresponding pulses (swinging between the levels approximately 0 V and +12 V) at TR6-collector.

On PERIOD function TR6 is 'inhibited' but the diode gate D12/D14 is 'enabled', by control termination K, so that pulses (from the L.F. output of pulse shaper type 77/310 treated in Chapter 3.5) received at termination 9 may operate TR7 for the production of corresponding pulses at TR7-collector.

Pulses produced at the common collector junction of TR6/TR7 pass by way of termination 7 to the multi-decade divider chain treated in Chapter 3.6. The pulses also pass via diode D8 and transistor TR9 to input 13 of NAND-gate X3(11), but only when control termination 6 is held at +13 V.

While no decade of the OSCILLATOR AND DIVIDER card (treated in Chapter 3.6) is selected, NAND-gate X3(11) is 'enabled' by means of termination J. Pulses from TR9-emitter then pass to output termination P (to feed termination 13 of the GATE CONTROL AND RESET card) and by way of inverted X3(8) and termination R to the standard frequencies output socket of the instrument.

When a decade of the OSCILLATOR AND DIVIDER card is selected, X3(11) is held 'enabled' by TR10 for the output of the selected decade to feed terminations P and R. Transistor TR10 is cut-off when control termination 6 or 8 is held at +13 V, but conducts to 'enable' X3(11) when both control terminations (6 and 8) are open circuit.

Emitter follower TR5 allows the output of X3(3) to operate X3(11) without first being frequency divided by decade X2: this can occur only when control termination 8 is held at +13 V.

For PERIOD function control termination K is held at +13 V so that pulses at termination 16 are produced by output signals of X1(6): for both TIMING functions control termination L is held at +13 V so that the pulses at termination 16 are produced by the output of X3(11) and passed by way of D11 and TR2.

The circuit of TR4 and TR5 is employed to produce a STORE TRANSFER pulse at termination 11 and 14 but is functional only when the STORE push-button (shown on diagram E69/25) is depressed to connect termination 12 to chassis-earth. The pulses are initiated upon receipt of a negative-going signal received at termination S upon completion of the gating period.

The amplitude of the pulse produced at termination 11 is approximately equal to the supply voltage level (+13 V), but that of the pulse produced at termination 14 is restricted to +5 V by potential divider R12/14. The two pulses serve to control the transfer of information within the COUNTER card.

3.8 STOP & START SHAPERS TYPE 77/320 (Drg. E69/01)

Input sockets START and STOP (SK1 and SK2 on SIGNAL PATH DIAGRAM E69/25) are for use only on functions TIMING B⟶C and COUNT when they may be used to start and stop the main signal-gating action, within the instrument. The 'START' socket feeds termination 15 and the STOP socket feeds termination 11 of card type 77/320.

The circuit of the card (diagram E69/01) comprises twin amplifier/pulse-shaper circuits, one operated by 'start' input-signals the other by 'stop' input-signals.

Termination 13 serves as control line input for both circuits; when it is held open circuit the amplifier/pulse-shapers are 'inhibited', when it is held at +13 V they are 'enabled'.

Because the two circuits are identical (except for terminations) only the start circuit containing TR1-3 and X1(6) will be described.

The action of the circuit is dependent upon the setting of the rear-panel-mounted SLOPE switch connected to terminations 14 and 16. The output of the circuit occurs at termination 7 and is a positive-going pulse of approximately 0.1 μs duration; this is initiated by the positive-going excursion of the input waveform when the SLOPE switch is set to +ve (termination 14 held at +13V: termination 16 open circuit) but from the negative going excursion when the SLOPE switch is set to -ve (termination 16 held at +13V : termination 14 open-circuit).

Signals received at termination 15 pass via a.c. - coupled amplifier TR1 to input 1 (strapped to inputs 2 and 4) of integrated Schmitt trigger stage X1(6).*

When the SLOPE switch is set to +ve, termination 14 is held at +13 V so that the bias at X1(6) input 1 is greater than +2 V and TR3 is held cut-off by current drawn via D1 and potential divider R10/R12.

For this condition the amplitude of X1(6) output pulses is not sufficient to change the state of TR3, which is a.c. - coupled by C7. However, the pulses drive inverter TR4 which feeds a.c. - coupled output transistor TR2. The differentiating action of C6/R8 ensures that for each positive-going output pulses of X1(6) a positive-going pulse (of approximately 0.1 μs duration) occurs at output termination 7.

When the SLOPE switch is set to -ve, termination 16 is held at +13 V so that TR2 is held cut-off; the bias at input 1 of X1(6) is then approximately +0.5 V.

Input pulses by way of amplifier/inverter TR1 operate the Schmitt trigger stage. Negative-going pulses at X1(6) output, differentiated by C7/R10, operate TR3 for the production of the poisitve going output pulses at termination 7.

The 'start' pulse output (termination 7) feeds input termination 6 of the GATE CONTROL AND RESET card type 77/600: the 'stop' pulse output (termination 6) feeds input termination F of the same card (type 77/600).

3.9. GATE, CONTROL AND RESET CIRCUIT TYPE 77/600 (Drg. E68/99)

Plug-in cards type 77/600 houses the gate control interfacing circuit, two flip-flops controlling the main gating action of the instrument, a monostable of the display timing circuit, and an inhibit timer and reset signal generator.

* Note. When an integrated circuit element is a Schmitt trigger stage the letters 'ST' appear inside the symbol and the integrated circuit reference number appears outside.

INTERFACING AND GATE CONTROL CIRCUIT

Two integrated circuit JK-flip-flops X2(13) and X2(8), arranged in inter-lock connection, form the control circuit for the main gate of the instrument. The 'clock' input of both stages (inputs 1 and 5) are linked together and receive the trigger pulses that initiate gating action.

The trigger pulses are received, by way of separate interfacing circuits, from different sources according to the particular function that the instrument is required to perform.

For functions FREQUENCY and PERIOD pulses received at termination 13 pass to the clock inputs of the flip-flops via NAND-gate X3(1) which is 'enabled' by a +13 V potential applied to control termination 7.

When function TIMING A⟶A is selected, pulses received at termination L pass to the flip-flop clock inputs via NAND-gate X3(4) held 'enabled' by +13 V at control termination J.

On functions TIMING B-C and COUNT the 'start pulse', received at termination 6 (and produced by the start pulse shaper of card type 77/320) or received at termination 11 (and produced by depression of the START push-button shown on diagram E69/25), feeds the clock inputs of the flip-flops by way of X3(10). A similar circuit, that of X3(13), receives the 'stop pulse' via termination F or 12. During the inhibit period of the instrument start pulse 'NAND-gate X3(10) is 'inhibited' by means of the potential produced at termination 16 which then holds TR6 conductive.

After a reset pulse has been received at the clear inputs of the flip-flops the logic levels at the outputs are: '0' at the Q output of flip-flops X2(13); '1' at the Q output of flip-flops X2(13) and X2(8).

The flip-flops having thus been reset, the first negative-going pulse (the 'start' pulse) received at their common clock inputs, triggers X2(13) so that the levels at its Q and Q outputs interchange: Q becomes '1' to produce the 'gate open level' at termination 8 and 'enable' both flip-flop X2(8) and NAND-gate X3(13), Q becomes '0' to 'inhibit' NAND-gate X3(16) and produce at termination 15 the 'complement of the gate open level' (which serves to cut-off TR2 of diagram E68/91 for illumination of the GATING LAMP).

The second negative-going pulse (the 'stop' pulse) received at the common clock inputs, triggers both flip-flops; the output level of flip-flops X2(13) inter-change for removal of the 'gate open level' (from termination 8) and its complement (for termination 15), and the Q output of flip-flop X2(8) swings to '0' to provide a negative-going signal at termination S.

This signal serves as 'store transfer trigger signal' with the exception that in the TF 2416/3 (Serial b.c.d. output) it serves as the 'print/punch command pulse'.

Both flip-flops remain insensitive to further input signals via their clock inputs as each holds the other 'inhibited', X2(13) held 'inhibited' by the Q output of X2(8), and X2(8) by the Q output of X2(13).

During the operation of the flip-flops for functions TIMING B⟶C and COUNT, integrator C13/R29 serves to delay the 'inhibiting' feedback to NAND-gate X3(10) so that the first trigger signal at the clock input of X2(13) is sustained sufficiently long to permit completion of the flip-flop trigger action. Integrator C19/R32 serves to delay the 'enabling' feedback to NAND-gate X3(13) and insures that the initial trigger action of flip-flop X2(13) is completed before a stop signal may be received via X3(13).

DISPLAY TIMING, INHIBIT TIMING AND RESET CIRCUIT

The negative-going signal produced (at the end of the gating period) at the Q output of X2(8) triggers the display time monostable circuit containing NAND-gate X1(3), transistors TR1 and TR2, and the front-panel-mounted DISPLAY TIMER potentiometer connected to termination 9 and shown on diagram E69/25.

During the stable state of the monostable X1(3) is held 'enabled' by the emitter potential of TR2. As the circuit is triggered the output of X1(3) swings to logic level '1' which cuts-off TR1 and TR2 collector currents; diode D12 clamps input 2 of X1(3) at approximately 0 V.

Provided that the ganged switch of the DISPLAY TIMER potentiometer is not set to INF (Infinity: switch open) C2 discharges via R4 and the potentiometer whose setting determines the capacitor discharge time and consequently the display time of the instrument.

Transistor TR1 becomes conductive when junction C2/R4 tends negative with respect to the emitter; therefore, TR2 conducts and X1(3) output swings to '1' thus hastening completion of C2 discharge and triggering the inhibit monostable by way of CC/D4.

The inhibit monostable, containing NAND-gate X1(8) and transistor TR3, may also be triggered by a similar negative-going signal received via C5/D5 (and produced upon depression of the RESET push-button connected to termination 10) or received via C8/D3 upon receipt of an external reset input signal at termination R (Note. Termination R is used only on special models of the instrument).

As the monostable is triggered, X1(8) output swings to '1' and produces a positive-going inhibit signal at termination 14 and, by means of inverter X1(6), the complement of this signal at termination 16. The change in output level of X1(8) causes TR3 to conduct and supply a negative-going pulse via C10 for momentary cut-off of TR5 and TR4 collector currents. Three pulses are thus produced; a positive-going pulse (amplitude approx. 12 V) at termination H, a positive-going pulse (amplitude approx. 5 V) at termination N, and a negative-going pulse (amplitude 2.5 V) at termination P. The duration of the three pulses is approximately 25 μs.

At the end of the inhibit period (approximately 4 ms, governed by the charging time of C9) TR3 is cut-off and its collector applies logic level '1' to input 10 of X1(8) so that the output of the NAND-gate reverts to '0' for removal of the inhibit signal and its complement from terminations 14 and 16.

3.10 COUNTER & DISPLAY CIRCUITS TYPE 77/700, 77/807 & 77/817 (Drg. E69/24)

Pulses from the main signal gate of the instrument are received at input termination 5 of the Counter card type 77/700 (circuit diagram E68/98). The Counter is initially reset by pulses received at terminations 7 and 13.

The Counter operates in conjunction with the circuits of the Display Control card type 77/817 (diagram E68/97) and Display card type 77/807 (diagram E68/96).

The circuit arrangement of these three inter-connected cards is shown in schematic form on diagram E69/24. Each card is represented by a rectangle marked with the appropriate type number of the card. The rectangle representing card type 77/817 is shown in chain lines as this card is housed in a socket mounted on card type 77/807.

Input pulses received at termination 5 of the Counter card (type 77/700) feed a chain of seven cascade-connected decades comprising one VHF counter decade and three dual MOS counter decades; on Counter circuit diagram E68/98

these, in order of progression along the chain, are TTL integrated circuit X1 (VHF or least significant digit decade) and MOS integrated circuit decade/ store modules X3, X4 and X5. Interfacing, for output pulses of the TTL decade to drive the cascade-connected MOS decades, is provided by the circuit of TR1 and TR2.

Integrated circuits X2 serves as a store for count information received in bcd form (via inputs 3,6,2 and 7 from decade X1; equivalent store circuits for the other decades are contained within X3 to X5.

The potential at termination 14 controls store X2; when it is held at approximately +5 V the bcd output information of X1 is present also at the output of X2 (outputs 1,14,11,8) when it is changed to approximately 0 V the b.c.d. information existing at the output of X2 is sustained (store condition) and X2 is held insensitive to changes in the output information of decade X1. The store circuits of the other decades are controlled in like manner by control termination 11: the two control lines are operated simultaneously.

The store associated with any decade may be selected for its four line output to feed terminations H,J,E and F: here the count information occurs in 1-2-4-8 b.c.d complement form. The stores are selected by means of control lines: terminations S,R,P,N,M,L and K corresponding to the least-significant decades. When termination S is held at approximately +13 V the four diode gates contain D1 to D4 and D7 to D10 are 'enabled' for the information of store X2 to pass to terminations H,J,E and F. Similar circuits for the other decade stores are housed within X3 to X5.

The stores are scanned (selected in turn) by means of a pulse that progresses around a ring circuit comprising seven transistor stages, each of which effectively operates as a half-monostable circuit.

This seven stage ring circuit, represented in schematic form on diagram E69/24 and in circuit form on diagram E68/97, is set into operation by a SCAN STARTER circuit as the instrument supply is switched on.

The SCAN STARTER circuit comprises a relaxation oscillator housed by card type 77/807 (circuit diagram E68/96) and formed by the circuit of neon-tube V1. A negative-going pulse from the oscillator passes by way of C1 (diagram E68/96) and termination 16 (diagram E68/97) and cuts-off TR1 collector current for a period determined by the time constant C1 (diagram E68/96) x R1 (diagram E68/97). For this period termination 2 (diagram E68/97) is held at approximately +13 V for selection of the most-significant-digit store and termination 1 is held at approximately +95 V (by the action of Zener diode D2 of diagram E68/96) to permit display of the corresponding numeral.

Throughout the TR1 cut-off period, digit information from the selected decade store passes (in 4-line parallel b.c.d. form) from terminations H,J,E, and F of the counter card type 77/700* to terminations 9,10,7 and 8 of the Display card type 77/807*. This information is received by integrated circuit X1 (diagram E68/96) which functions as b.c.d./decimal converter; its ten digit-output lines (0 to 9) feed the corresponding parallel connected digit-cathodes of indicator tubes V2 (most significant digit tube) to V8 (least significant digit tube). Decimal point control lines for tubes V5 to V8 are provided at terminations 21 to 24.

While termination 1 (diagram E68/97) is held at approximately +95 V TR1 conducts and neon tube V2 is 'struck' for display of the most significant digit.

Throughout the cut-off period of TR1 (diagram E68/97), transistors TR2 to TR7 are held conductive and so hold display tubes V3 to V8 (diagram E68/96) in the non-illuminated condition.

* Refer to diagram E69/24

At the end of the cut-off period TR1 (diagram E68/97) conducts and a negative-going pulse passes via C2 to cut-off TR2. Thus the function of decade-store selection and display-tube illumination is passed to the second transistor of the seven storage ring circuit; therefore, the second most significant digit is momentarily displayed. In this manner all digits are, in turn, displayed. The pulse that is produced as the last transistor of the ring again conducts, is fed back to TR1 so that the store-scanning/display process for the seven digits is recurrent.

Transistors TR8 and TR9 serve to permit only one pulse to circulate around the ring. During the scanning of the first six digits one or another of the transistors TR1 to TR6 is non-conductive and so provides bias (via R4 or R8 or R12...) to hold TR9 conductive; TR7 is also conductive and holds TR8 cut-off. When the sixth most significant digit has been displayed and TR6 again conducts, and provided that none of the transistors TR1 to TR5 is held non-conductive by a further pulse in the ring TR9 base bias is automatically removed. Transistor TR9 is therefore cut-off and the circulating pulse cuts-off TR7, which in turn causes TR8 to conduct thus 'inhibiting' receipt of any further pulse from TR6 during the cycle. Subsequently the circulating pulse is passed back from TR7 to TR1, whereupon the TR9 base bias is restored.

When an incorrect setting of the controls is detected (see Chapter 3.3) termination R is held at a potential such that diode D8 conducts to hold TR9 conductive; the normal action of the scanning circuit is thus 'inhibited' and so no pulse is passed back to TR1.

The display circuit (diagram E68/96) contains ballast resistors R19 and R20. Once the scanning circuit has been set into operation, the relaxation oscillator circuit of V1 is effectively 'switched off' by the potential developed across R19/R20 as they pass the indicator tube current. However, while the ring of scanning circuit (diagram R68/97) is 'inhibited' no tube current flows via R19/R20 and so the relaxation oscillator is free to operate and delivers pulses to the ring circuit; but because the period of oscillation is much greater than the time normally taken for a pulse to circulate the ring, the frequency of illumination of each indicator tube is relatively reduced and consequently the display appears dim.

The circuits of TR8 and TR9 (diagram E68/96) are required when the instrument carries a data logging facility*. Transistor TR8 momentarily conducts to produce a negative-going 'clock-signal' (or 'digit marker pulse') at termination 19 whenever the circulating pulse in the ring circuit is passed from one stage to the next.

Transistor TR9 is momentarily cut-off to produce a positive going sequence start signal (or 'scan marker pulse') at termination when a negative going potential change occurs at termination M. This change is produced as the pulse circulating in the scanning circuit (diagram E68/97) passes to TR1 at the start of each scanning cycle.

3.11. DATA OUTPUT FACILITY

Data output is an optional facility that is provided only if it has been initially ordered. Either of two types of outputs may be fitted: serial output (TF 2416/3) or parallel output (TF 2416/4) . The circuits for the two types of output are described below.

3.11.1 Serial B.C.D. Interface Type 77/910 (Drg. E69/33)

This interface circuit is housed by card type 77/910 (diagram E69/33). It consists of four inverters TR1 to TR4 operated in parallel by the b.c.d. $\overline{1}$, $\overline{2}$, $\overline{4}$ and $\overline{8}$ output lines of the Counter card. The outputs of the interfacing circuit feed the rear panel mounted data logging output socket of the instrument*.

* For decimal point selection refer to Section 3.3 and diagram E69/26 and E68/91
* Refer to Chapter 1.2.5

The data is presented at the socket in serial form in the order most-significant-digit to least-significant-digit.

3.11.2 Parallel B.C.D. Interface Type 77/900 (Drg. E69/27)

The parallel b.c.d. interface circuit is housed by card type 77/900 and is represented on diagram E69/27. It contains four inverters, TR4 to TR7, operated in parallel by the b.c.d. $\overline{1}$, $\overline{2}$, $\overline{4}$ and $\overline{8}$ output lines of the Counter card.

The inverters feed separate seven-stage integrated circuit shift registers (X1 to X4). The seven outputs of each shift register feed the rear panel mounted data logging output socket of the instrument*.

Operation of the four shift registers is controlled by integrated circuit X5, which contains two flip-flops externally linked for inter-lock action. This integrated circuit employs the auxiliary circuits of TR1 to TR3: the action of the interface circuit is as follows -

At the end of the gating period of the instrument a negative-going pulse (from card type 77/600 termination S) is received at termination 14 and serves to reset the inter-lock connected flip-flops of X5 and the four shift registers X1 to X4.

When the next scanning cycle is commenced, a 'scan marker pulse' (positive-going) is received at termination 16. The signal passes via inverter TR1 and triggers the flip-flop circuit; whereupon X5 output 8, swings from logic level '1' (the next state) to logic level '0'. This logic level change 'enables' the circuit of TR2 for control of the normally conductive inverter TR3.

As the first digit of the scanning cycle is selected for display (most significant digit) a 'digit marker pulse' (negative-going) is received at termination 15. This pulse is differentiated by C2/R7-R8 and initiates momentary conduction by TR2 and consequently momentary cut-off of TR3 for the production of a positive-going pulse at TR3 collector: the pulse simultaneously clocks integrated circuits X1 to X4 so that each of the four 'bits' of the b.c.d. digit information are accepted into the first stage of their respective shift registers.

The four shift registers are progressively clocked to store the remaining six digits, as further 'digit marker pulses' are received during the scanning cycle. At the end of the cycle a second 'scan marker pulse' is received at termination 16. This pulse triggers the flip-flop circuit: a negative-going potential change occurs at output 3,9 and 14 (the signal feeds termination AA and serves as 'print/punch command' output signal) and output 8 swings back to logic level '1' to 'inhibit' the circuit of TR2. The flip-flop circuit is then in the locked condition and remains insensitive to further 'scan marker pulses' until, at the end of a subsequent gating period of the instrument, another negative-going pulse is received at termination 14 whereupon reset action and a new cycle are initiated within the b.c.d. interface circuit.

NOTE

Circuit Logic Levels '0' and '1' as used in the foregoing circuit description are defined below.

General Control Circuits (Less MOS circuits)
Logic '0' - 0 V to +0.4 V
Logic '1' - +2.5 V to 5 V

MOS Circuits (Each output is a current drive)
Logic '0' - effectively an open circuit condition
Logic '1' - +0.5 mA to +1.5 mA (short circuit to 0 V line)

* Connections at this socket are listed in Chapter 2.13.

Chapter 4

Maintenance

4.1 INTRODUCTION

This section contains information on preventive maintenance and performance checks to ensure that the instrument will continue to meet its specification.

The performance checks include sufficient adjustment procedure to cover the most important section of the specification, however performance limits quoted are for guidance only and should not be taken as guaranteed performance specifications unless they are also quoted in the Data Summary section.

4.2 ACCESS AND LAYOUT

The instrument case is in two sections each secured by two fixing screws at either side of the unit. Removal of the top section gives access to the power unit and vertically mounted plug-in printed circuit boards and their preset controls; removal of the lower section gives access to the socket pins of the plug-in boards and to the preset control (R16) of the front panel switch assembly.

WARNING

Whenever the instrument is operated with the case removed, ensure that no physical contact is made with exposed connections of the mains supply circuit (particularly the tags of the main transformer) and the exposed connection of the internal +240 V d.c. supply indicated on layout diagram S69/84.

4.2.1. Fuse replacement

A cartridge fuse, connected in the LIVE line of the mains input circuit, is housed in a screw type container accessible above the mains cable entry in the rear panel. The appropriate fuse rating depends upon the supply voltage:

Supply Voltage	Fuse Rating	Marconi Part Number
100-125 V	600 mA slow blow	TF 2416/FPP/23402
200-250 V	300 mA slow blow	TF 2416/FPP/23401

4.2.2 Plug-in Module Location

The position of the various plug-in modules are indicated in layout diagram S69/84.

The modules are fitted with coloured finger-grip/spacers at the top of the printed circuit boards. Table 4.1 gives the colour coding for each board. The chassis is also marked with the appropriate colour beside the corresponding sockets to simplify location.

Type	Title	Colour Code	Quantity
77/010	Front Panel Assembly	-	1
77/020	Rear Panel Assembly	-	1
77/220	Power Supply	-	1
77/300	Pre-Amplifier	-	1
77/310	Pulse Shaper	Red	1
77/320	Start/stop Shapers	Pink	1
77/400	Divider Interface	Grey	1
77/500	Oscillator & Divider	Green	1
77/600	Gate Control & Reset	Beige	1
77/700	Counter	Blue	1
77/807	Display	-	1
77/817	Display Control	-	1

TABLE 4.1 P.C.B. Colour Coding

Alternative versions of the TF 2416 will be fitted with the appropriate alternative plug-in card as indicated below -

TF 2416/1 : Card type 77/511 Oscillator and Divider (Green) fitted in place of card type 77/500.

TF 2416/2 : Card type 77/510 Oscillator and Divider (Green) fitted in place of card type 77/500.

TF 2416/3 : Card type 77/910 Serial BCD Interface added.

TF 2416/4 : Card type 77/900 Parallel BCD Interface added.

4.3 PERFORMANCE CHECKS & ADJUSTMENT PROCEDURE

4.3.1 Preset D.C. supplies—Adjustment

Power Unit type 77/220 provides three stabilized low tension supplies for the semiconductor circuits, and one non-stabilized high tension supply for the digital indicator tubes.

The three low tension supplies may be monitored at the socket that houses plug-in card type 77/320 (colour coded PINK). The voltage range, monitoring pin, and where applicable, the control at which voltage adjustment may be made, are listed below for each low tension supply.

Low Tension Supply	Monitoring Pin (77/320 Socket)	Voltage Adjustment Control (on Power Unit)
+5 V ±0.25 V	Pin 1	-
+13 V +0.2 V −0 V	Pin 3	R2*
−16 V +0 V −0.2 V	Pin 4	R3*

NOTE Pin 2 (77/320 socket) is the 0 V or common line of the three supplies

Recommended voltmeter (TF 2670 Digital Multimeter)

Observe meter range and supply polarity when connecting voltmeter

The high tension supply (+240 V ±15 V) may be monitored between the CHASSIS-EARTH tag secured to the top of Pre-Amplifier type 77/300 (voltmeter negative) and the H.T. TEST POINT (positive end of power unit capacitor C1): both connection points are indicated on layout diagram S69/84.

4.3.2 Pulse Shaper Preset Control—Adjustment

The plug-in Pulse Shaper card type 77/310 carries one preset control - potentiometer R2. The control may be adjusted by means of a screwdriver or trimmer tool which may be inserted through a small hole in the right hand side plate of the instrument when the case has been removed (for hole location refer to layout diagram S69/84).

NOTE The instrument supply should be switched on for a stabilization period of at least five minutes prior to control adjustment.

To adjust the control proceed as follows.

* For location see Layout Diagram S69/84.

(1) Check that the knob of the TRIGGER LEVEL control is secured on its spindle such that the angular rotation available in clockwise and anti-clockwise directions about the centre mark (excluding the additional angular rotation for operation of the L F switch) are equal.

If necessary re-position and secure the knob (for knob removal refer to Chapter 5.2.2)

(2) Set the rear-mounted STD switch to INT, depress the FREQ push-button and set the range switch to '10^5'.

(3) Apply a standard frequency sinusoidal 1 kHz 10 mV r.m.s. signal to the coaxial A INPUT socket.

(4) Set the DISPLAY TIMER to MIN and momentarily depress the RESET push-button.

At this juncture the GATE OPEN neon lamp should be flashing; indicating a fast and consistent cyclical gating action.

(5) Set the TRIGGER LEVEL control to the middle position and set the adjacent slope switch to '∿'.

(6) Slowly turn Pulse Shaper potentiometer R2 slowly clockwise and then anti-clockwise while observing the display. A recurrent display of 00001.00 should be obtainable between two settings of the control. The control may be turned in either direction several times until the two positions are determined; then set the control midway between these two positions.

(7) Slowly turn the TRIGGER LEVEL control anti-clockwise while observing the display. At first the display should be 00001.00 but a position should be reached for which the display changes to zero; note this position of the control. Now slowly turn the control clockwise, the display should revert to 00001.00 but beyond the centre mark a position should be reached for which the display changes to 00000.01; note this position. The two noted control-positions should be approximately equi-distant about the centre mark on the panel. If necessary R2 may be re-adjusted to obtain the required performance of the TRIGGER LEVEL control.

4.3.3 Oscillator Preset Control—Adjustment

Plug-in Oscillator cards type 77/500 (TF 2416) and 77/511 (TF 2416/1) carry a preset trimmer control mounted on the side farthest from the power unit.

On card type 77/511 the control is contained in a can unit with a small hole in the top giving access for a trimmer tool.

In TF 2416/2 versions the trimmer control is housed in the oven unit, which is mounted on the power unit. A small hole in the top of the oven gives access for a trimmer tool.

NOTE The instrument supply should be switched on for a stabilization period of at least fifteen minutes prior to control adjustment.

To adjust the preset trimmer proceed as follows

(1) Set the rear-mounted STD switch to INT, depress the FREQ A push-button and set the range switch to '1' and the DISPLAY TIMER to INF.

(2) Connect one beam of a double-beam oscilloscope between the TEST 1 MHz output socket and chassis, and the second beam to a standard frequency source providing 1 MHz signals of amplitude suitable for oscilloscope display.

(3) Set the oscilloscope so that it is triggered by signals from the standard frequency source.

(4) Compare the oscilloscope traces and, by use of a suitable trimmer tool, adjust the setting of the trimmer until the frequency of the TEST 1 MHz signal is identical to that of the standard frequency signal.

NOTE If the TEST 1 MHz frequency changes as the tool is removed re-adjust the control, allowing for the effect of tool capacitance, so that the two signals are identical in frequency when the tool has been removed.

(5) Allow several minutes to elapse for oscillator stabilization, then check that no drift in oscillator frequency has occurred, if necessary repeat the procedure from (4) above.

4.3.4 Preset Display Dimming Control—Adjustment

The display dimming circuit operates if one or more of the function push-buttons (FREQ, PERIOD, TIMING or COUNT) are depressed at any one time, or if the extreme anti-clockwise position of the range switch is used on PERIOD function. Results shown by the dim display are invalid.

The action of the circuit is controlled by a preset potentiometer that is mounted on the underside of the Front Panel Assembly board type 77/010. The control, which is situated near the rear of the RESET push-button, is accessible for adjustment from beneath the instrument when the lower section of the case has been removed.

To adjust the preset control proceed as follows.

(1) Set the range switch to '1'.

(2) Simultaneously depress push-buttons FREQ and PERIOD (both push-buttons should remain locked in the depressed position).

(3) By use of a small screwdriver turn the preset potentiometer (R16 of card type 77/010) fully clockwise: the display should now be dim.

(4) Slowly turn the potentiometer anti-clockwise until the position is reached for which the display reverts to normal brightness; then turn the control back (clockwise) through approximately 30° (the display should now be dim).

(5) Release the two depressed push buttons: the display should revert to normal brightness.

(6) The display should dim when the push-button of each pair listed below are depressed.

PERIOD and TIMING A→A

TIMING A→A and TIMING B→C

TIMING B→C and COUNT

(7) Set the range switch to the extreme anti-clockwise position and depress the PERIOD push button: the display should again become dim.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter of the manual, although not an exhaustive treatment of the subject of instrument repair, deals with certain fundamental procedures for fault location, with a number of malfunctions that could arise in the display system and with the procedure for consequent repair.

The location of the various modules is fully explained in Chapter 4.2.2 of the Maintenance section of this manual.

Performance limits quoted are for guidance only and should not be taken for guaranteed performance specifications unless they are also quoted in Data Summary Chapter 1.2.

In case of difficulties which cannot be resolved with the aid of this manual, please contact our Service Division at the address stated on the back cover, or your nearest Marconi Instruments representative quoting the type and serial number of the instrument.

5.2 FAULT FINDING

In many cases, non-existant faults are due to incorrect settings, ensure therefore that the adjustment procedure outlined in Chapter 4.3 has been correctly carried out.

The nature of a fault will often be apparent from its symptom (for example a faulty readout tube or a gross error on the display time will quickly be seen) and in general faults concerning decades, memory or readout will show in the display.

5.2.1 Internal Supply Voltages

Malfunction of the instrument can be caused by incorrect voltages of the internal supplies, therefore a check of the voltages should be made prior to specific circuit functions investigation. Diagram E69/26 indicates the supply lines to each module.

Measurement and adjustments of the internal supply voltages are outlined in Chapter 4.3.1.

5.2.2 Oscillator and Pulse Shaper Adjustment

If time dependent measurements are suspect the frequency of the reference oscillator should first be checked and if necessary adjusted (see Chapter 4.3.3).

When the oscillator frequency has been checked and incorrect results are still obtained on functions for which signals are received by way of the A INPUT socket, the setting of the Pulse Shaper control should be checked in accordance with Chapter 4.3.2.

NOTE 16 way double-sided extension boards are available from our Service Division (for address see back cover). Part No. TF 2416/FPP50001.

5.2.3 Control Line Voltages

The functions of the instrument are internally selected by a number of control lines which may be held at either of two 'logic states'.

Logic state '1' represents +13 V with respect to chassis.
Logic state '0' represents ⩽0 V with respect to chassis.
'C' represents open-circuit decimal point line.
'-' represents unused circuit.

The particular voltage combination of these lines determines the instrument function and are shown in Table 5.1.

Function	Range	Sub-circuit Type 77/010 Terminations (Shown on Drg. E69/26) T	R	N	S	X	U	W	L	20	19	AA	AB	Z	Y	17	22	21	24
Freq.	MHzx10	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	C	C	C
"	1 MHz	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	C	C	C
"	10 "	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1	C	C	1
"	10^2 "	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	C	1	C
"	10^3 "	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	C	C
"	10^4 "	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	C	C	1
"	10^5 "	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	C	1	C
"	10^6 "	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	C	C
"	10^7 "	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	C	C	C
Period	1 period*	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	C	C	1
"	10 "	0	1	1	1	0	0	0	0	0	0	1	0	0	0	1	C	C	1
"	10^2 "	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	C	C	1
"	10^3 "	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	C	C	1
"	10^4 "	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	C	C	1
"	10^5 "	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	C	C	1
"	10^6 "	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	C	C	1
"	10^7 "	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	C	C	1
Timing A A	µs	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	C	C	C
"	1 ms	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	1	C	C
"	10 "	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	C	1	C
"	10^2 "	0	0	0	0	1	1	1	0	0	0	0	1	0	0	1	C	C	1
"	10^3 "	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	C	C	C
"	10^4 s	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	C	1	C
"	10^5 "	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	C	C	1
"	10^6 "	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	C	C	C
"	10^7sx10	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	C	C	C
Timing B C	µs	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	C	C	C
"	1 ms	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	C	C
"	10 "	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	C	1	C
"	10^2 "	0	0	0	0	1	1	0	1	0	0	0	1	0	0	1	C	C	1
"	10^3 "	0	0	0	0	1	1	0	1	0	0	0	0	1	0	1	C	C	C
"	10^4 s	0	0	0	0	1	1	0	1	0	0	0	0	0	1	1	C	1	C
"	10^5 "	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	C	C	1
"	10^6 "	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	C	C	C
"	10^7sx10	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	C	C	C
Count	-	1	0	0	0	0	1	0	1	-	-	-	-	-	-	-	-	-	-

*The extreme anti-clockwise position 'µs' of the Range switch should not be used on Period function: refer to NOTE in Chapter 2.4(7).

TABLE 5.1 CONTROL LINE VOLTAGES

For each function on which a fault condition is manifested, the control line voltages should be measured and checked against the corresponding voltage combination appearing in the table. This check should be carried out prior to investigation into the circuit operation of any individual module.

Sub-circuit type 77/010, referred to in Table 5.1, may be located by reference to Layout Diagram S69/84, and terminations at the edge-connector of this circuit by reference to Board Layout Diagram BL77/010.

The control lines feed terminations of the various modules as indicated on diagram E69/26, and in some instances it may be found more convenient to measure the control line voltages at these alternative connections.

The circuit at which the control lines originate is shown on diagram E68/91 and is described in Chapter 3.3.

5.2.4 Plug-in Cards

The circuits of the various plug-in cards are described in Chapter 3.4 to 3.11.2. If a fault has been traced to one of these cards and the location of the individual components of the card are required, refer to the corresponding board layout diagram, which is provided together with the circuit diagram in Chapter 7.

5.2.5 No-count Condition and Malfunction of the Display System

Automatic display dimming to indicate incorrectly set controls is incorporated, however if a dim display is shown for a correct setting of the controls then the display dimming control should be checked for adjustment (see Chapter 4.3.4). Circuits associated with the display dimming are treated in Chapter 3.3 (para 7 and 8) and Chapter 3.10.

Table 5.2 provides a systematic, although not an exhaustive fault location procedure, dealing with some of the display system malfunctions that might arise.

5.3 DISMANTLING PROCEDURE

Integrated circuits and semiconductor devices are used throughout this instrument and, although these have inherent long term reliability and mechanical ruggedness, they are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as prolonged soldering, strong r.f. fields or other forms of radiation, the use of insulation testers, and accidentally applied short circuits.

When removing integrated circuits a special soldering iron should be used as all leads must be unsoldered together to release the device.

WARNING

Switch off the supply and disconnect the supply cable before commencing to dismantle the instrument.

Instructions for case removal are given in Chapter 4.2, further dismantling instructions are given in the following sections.

FAULT	CHECK		REFERENCE	NEXT CHECK
No count register on function -	(i)	Osc. O/P at 10 MHz test point		If present check (ii)
	(ii)	Setting of STD switch	Chaper 2.4(14)	If correct check (iii)
	(iii)	Oscillator circuit	Chapter 3.6	
	(iv)	Presence of divide O/P	Termination 13 on Card 77/600	If correct check (v)
	(v)	Control line voltage	Chapter 5.4	See (vi)
FREQ PERIOD TIMING	(vi)	If fault is manifest on Period function by use of test facility	Chapter 2.5	Then (vii)
	(vii)	Integrated circuit X2	Card 77/400	If correct check (viii)
	(viii)	X2 associated components		If correct check (ix)
	(ix)	Integrated circuit X1 and X2	Card OSC. & DIVIDER (Chapter 3.6)	
No display illumination	(i)	Supplies	Chapter 5.2	Not present check (ii)
	(ii)	Mains fuse	Chapter 2.3.2	or (iii)
	(iii)	Stabilised circuit +13 V supply	Chapter 3.2	If correct (iv)
	(iv)	Scanning pulse action	Card 77/817 (Chapter 3.10)	If correct (v)
	(v)	Relaxation Osc.	Card 77/807	or (vi)
	(vi)	TR1	Card 77/81 (Chapter 3.10)	If correct (vii)
	(vii)	Each display tube for anode/cathode S/C	Circuit diagram E68/96	
Multi-image display	(i)	For incorrect logic output on Card 77/700	Chapter 3.10	Faulty integrated circuit
	(ii)	Integrated circuit decoder X1 on Card 77/807	Chapter 3.10	
	(iii)	For anode/cathode short circuit on indicator tubes	Circuit diagram E68/96	

TABLE 5.2 FAULT FINDING CHART

5.3.1 Plug-in Cards Removal

Each vertically mounted plug-in card that bears coloured finger-grip/spacers, may be withdrawn by simply holding it at either end and gently pulling it upwards away from the chassis. The vertically mounted board type 77/817 may be withdrawn in a similar manner from its socket on board type 77/807.

In instruments fitted with data output facility an additional plug-in card (type 77/910 for TF 2416/3 ; type 77/900 for TF 2416/4) is mounted beside the supply switch push-rod. It may be unplugged and withdrawn from the top of the instrument when the two countersunk screws with spacers and nuts which secure it to the adjacent side plate of the instrument, have been removed.

5.3.2 Removal of Front Panel, Display Board and Pre-Amplifier

Proceed as follows -

(1) Remove the three control knobs.
Each control knob is secured by a screw driven through the top of the knob and into the end of its spindle: the screw head is covered by a cap that may be pulled out by means of the finger nails or thin bladed implement.

NOTE When the knob is later refitted refer to Chapter 4.3.2(1) for the necessary position.

(2) Withdraw the four panel-fixing screws (one near each corner of the panel) and remove the front panel.

(3) Withdraw the two sub-panel fixing screws that normally lie approximately below the front panel legends A INPUT and TRIGGER LEVEL.

(4) Pull forward the sub-front panel with its surround until the assembly is unplugged from the main chassis-unit. The horizontally mounted Display Board type 77/807 (housing the indicator tubes, and socket for the vertically mounting Display Control board type 77/817) may now be unplugged from its socket.

(5) Remove the screw that secures an earth-lead to the top of the Pre-Amplifier unit type 77/300; then unplug the unit by pulling it upwards from the main chassis-unit.

NOTE For correct performance of the unit it is essential that the earth-lead be re-connected when the instrument is re-assembled.

5.3.3 Rear Panel Removal

Withdraw the four rear-panel fixing screws and pull back the rear panel assembly until it is unplugged from the main chassis-unit.

5.3.4 Power Unit Removal

First ensure that the instrument has been disconnected from the supply then proceed as follows -

CAUTION

Removal of the Power Unit necessitates the disconnection of a number of soldered leads; therefore, removal of the unit should be effected only when it is essential. When the unit is refitted the lead connections should be carefully checked prior to switching on the supply.

Locate the socket that receives the rear panel assembly: unsolder the BROWN lead (supply input wire) from socket-pin 1, and the BLUE lead (supply-input wire) from socket-pin 3. Locate the socket that receives the Display Board type 77/807: unsolder the power unit H.T. lead from socket-pin 5, and the chassis-earth lead from socket-pin 2.

Four leads from the power units are terminated on the adjacent socket that houses card type 77/320. Unsolder these leads; the lead colours and pin-connections are given below.

Power Unit Lead Colour/s	Line Voltage	77/320 socket Pin No.
Black/White	(+5 V line)	1
Black	(0 V line)	2
Blue/Black	(+13 V line)	3
Violet/Black	(-16 V line)	4

The power unit may be removed when the four screws that secure it to the main chassis-unit have been withdrawn: these screws are accessible from the underside of the instrument.

5.4 PACKAGING FOR RESHIPMENT

In the event of the equipment being returned for servicing it should be packed in the original shipping carton and packing material. If this is not available wrap the instrument in heavy paper or plastic and place in a rigid outer box of wood, fibreboard or very strong corrugated cardboard. Use ample soft packing to prevent movement. Provide additional support for projecting parts to relieve these of unnecessary shock. Close the carton securely and seal with durable tape. Mark the shipping container FRAGILE to ensure careful handling.

Chapter 6

Replaceable parts

6.1 INTRODUCTION

The TF 2416 consists of a number of sub-assemblies and are listed in the order shown below. In this chapter only, each sub-assembly is designated an identification number in the sequence Z1 to Z16 as follows:-

Z1	-	Front Panel Assembly	77/010 (DRG. E68/91)
Z2	-	Rear Panel Assembly	77/020 (DRG. E68/93)
Z3	-	Power Supply	77/220 (DRG. E68/92)
Z4	-	Pre-amp	77/300 (DRG. E68/95)
Z5	-	Pulse Shaper	77/310 (DRG. E68/94)
Z6	-	Stop and Start Shapers	77/320 (DRG. E69/01)
Z7	-	Divider Interface	77/400 (DRG. E68/100)
Z8	-	Oscillator and Divider	77/500 (DRG. E69/02)
Z9	-	Oscillator and Divider	77/510 and 77/511 (DRG. E69/22) (TF 2416/2 & /1)
Z10	-	Gate, Control and Reset	77/600 (DRG. E68/99)
Z11	-	Counter	77/700 (DRG. E68/98)
Z12	-	Not Allocated	
Z13	-	Display	77/807 (DRG. E68/96)
Z14	-	Display Control	77/817 (DRG. E68/97)
Z15	-	Serial B.C.D. Interface	77/910 (DRG. E69/33) (TF 2416/3 only)
Z16	-	Parallel B.C.D.Interface	77/900(DRG. E69/27) (TF 2416/4 only)

For the purpose of ordering spares and to avoid ambiguity, the complete reference number of a part consists of the sub-assembly indicator number followed by the circuit reference number.

e.g. Z1/D1 is a U2973/2 whereas Z3/D1 is a BYX10

The circuit reference numbers are listed in the alpha-numerical order. The following abbreviations are used:-

C	capacitor	S	switch
D	diode	SK	socket
FS	fuse	T	transformer
HS	high stability	TR	transistor
L	inductor	V	indicator
LP	lamp	X	integrated circuit

Note - All tolerances quoted are ± unless otherwise indicated.
The Ohm unit of resistance is not indicated in this stocklist.

16 way double-sided extension boards are available from our Service Division (for address see back cover).
Part No. TF 2416/FPP50001.

6.2 ORDERING

When ordering replacements or spare parts, address the order to -

Marconi Instruments Service Division
The Airport
Luton, Bedfordshire

or to your nearest representative. Please specify the following information for each part required -

(i) Type of instrument
(ii) Circuit Reference Number e.g. Z1/LP1
(iii) Description e.g. Neon Gating Lamp
(iv) M.I. Part Number e.g. TF 2416/FPP/23701

If a part is not listed, state its function, location and description when ordering.

Spares supplied against M.I. Part Numbers are electrically interchangeable with those originally fitted, but may not always be identical.

6.3 PARTS LIST

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z1 - FRONT PANEL ASSEMBLY TYPE 77/010 (DRG. E68/91)			
Diodes			
D1,2	U2973/2	-	28101
Indicator			
LP1	Neon	Gating Lamp	23701
Resistors			
R1	33k 5% 0.25W HS	Carbon	24001
R2-6	24k 5% 0.25W HS	Carbon	24002
R7	8.2k 5% 0.25W HS	Carbon	24003
R8	3.9k 5% 0.25W HS	Carbon	24004
R9,13,14	10k 5% 0.25W HS	Carbon	24005
R10	220k 5% 0.25W HS	Carbon	24006
R11	100k 5% 0.25W HS	Carbon	24007
R12	82k 5% 0.25W HS	Carbon	24008
R15	12k 5% 0.25W HS	Carbon	24009
R16	4.7k 20% 0.25W	Carbon Lin.	25001
R17,18	150 5% 0.25W HS	Carbon	24010
R19	500k 20% 0.2W	Carbon Lin Variable with ON/OFF switch	25002*
Switches			
S1(A-D)	2p 9 way rotary	Range switch	23100
S2	1p ON/OFF	-	*
S3-6	4x1p changeover	Push-button bank	23101
S7-11(A-D)	5x4p changeover	Push-button bank	23102
Sockets			
SK1,2	50S/156 (black)	Test socket	23001
Transistors			
TR1	BC108	-	28201
TR2	C407	-	28202

* R19 is ganged to S2 Common Part No. 25002

Z2 - REAR PANEL ASSEMBLY TYPE 77/020 (DRG. E68/93)			
Capacitor			
C1(A-C)	0.1 + 0.005 + 0.005 µF (250V)	Suppressor capacitor	26001
Fuse	Rating		
FS1	300mA or	Slow blow	23401
	600mA	Slow blow	23402
Inductors			
L1,2	-	Mains choke	43201
Switches			
S1	2p ON/OFF	'Power' push-button	23103
S2-4	1p 2 way toggle	-	23104
Sockets			
SK1-4	BNC	-	23002

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z3 - POWER SUPPLY TYPE 77/220 (DRG. E68/92)			
Capacitors			
C1	8µF (350V)	Electrolytic	26002
C2	800µF (40V)	Electrolytic	26003
C3	2000µF (16V)	Aluminium foil	26004
C4,5	250µF (40V)	Aluminium foil	26005
C6,7	100µF (3V)	Tantalum	26006
C8-10	15µF (16V)	Tantalum	26007
Diodes			
D1,6	BYX10	-	28102
D2,5,7,8	1N4002	-	28103
D3,4	1N4001	-	28104
Resistors			
R1	470k 5% 0.25W HS	Carbon	24011
R2,3	220 20% 0.25W	Carbon Lin.	25003
Transformer			
T1	Mains transformer	-	43101
Integrated Circuits			
X1	L036T1	-	28401
X2	L005T1	-	28402
X3	L037T1	-	28403
Z4 - PRE-AMP TYPE 77/300 (DRG. E68/95)			
Capacitors			
C1	0.1µF 10%(400V)	Metalised Polyester	26008
C2,11	3.3µF (16V)	Tantalum	26009
C3,6-8	0.047µF +50% -25%	Polystyrene & Ceramic	26010
C4	33pF 10%	Ceramic	26011
C5	1000pF 20%	Ceramic	26012
C9	33µF (10V)	Tantalum	26013
C10	100µF (3V)	Tantalum	26006
C12	150pF 10%	Ceramic	26014
Diodes			
D1,2	BAW62	-	28105
D3	BZY88/C7V5	-	28317-603
D4	BZY88/C4V7	-	28371-373
Resistors			
R1	500k 20% 0.2W	Carbon Lin.	25002*
R2	56k 5% 0.125W	Carbon film	24012
R3,21	10 5% 0.125W	Carbon film	24013
R4,7,20	3.9M 10% 0.125W	Carbon film	24014
R5	1M 5% 0.125W	Carbon film	24015
R6	220k 5% 0.125W	Carbon film	24016
R8	470k 5% 0.125W	Carbon film	24017
R9	2.2k 5% 0.125W	Carbon film	24018
R10	680 5% 0.125W	Carbon film	24019
R11	100 5% 0.125W	Carbon film	24020
R12	150 5% 0.125W	Carbon film	24021
R13,17	820 5% 0.125W	Carbon film	24022
R14	220 5% 0.125W	Carbon film	24023

* R1 ganged to switch S1; common part number 25002

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z4 - Pre-Amp Type 77/300 (DRG. E68/95) (cont.)			
Resistors (cont.)			
R15	1.5k 5% 0.125W	Carbon film	24024
R16	47 5% 0.125W	Carbon film	24025
R18	18k 5% 0.125W	Carbon film	24026
R19	470 5% 0.125W	Carbon film	24027
Switches			
S1	1p ON/OFF		*
S2(A-B)	2p 3 way toggle		23105
Socket			
SK1	BNC	-	23003
Transistors			
TR1	2N5486	-	28203
TR2,3	BFY90	-	28204
Z5 - PULSE SHAPER TYPE 77/310 (DRG. E68/94)			
Capacitors			
C1	2.2µF (20V)	Tantalum	26015
C2-5,7,9,10	0.047µF +5% -25%	Polystyrene & Ceramic	26010
C6	33µF (10V)	Tantalum	26016
C8	15µF (20V)	Tantalum	26017
Diodes			
D1	BZY88/C4V7	-	28371-373
D2	U2973/2	-	28106
D3	BAW62	-	28105
D4	OA202	-	28337-534
Resistors			
R1	9.1k 5% 0.25W HS	Carbon	24028
R2	1k 20%	Carbon Lin.	25004
R3,20,23	1.5k 5% 0.25W HS	Carbon	24029
R4	4.3k 5% 0.25W HS	Carbon	24030
R5	1M 5% 0.25W HS	Carbon	24031
R6	15k 5% 0.25W HS	Carbon	24032
R7,17	1k 5% 0.25W HS	Carbon	24033
R8	1.8k 5% 0.25W HS	Carbon	24034
R9	220 5% 0.25W HS	Carbon	24035
R10,12	10 5% 0.25W HS	Carbon	24036
R11	430 5% 0.25W HS	Carbon	24037
R13	200 5% 0.25W HS	Carbon	24038
R14	100 5% 0.25W HS	Carbon	24039
R15,21,22	2.2k 5% 0.25W HS	Carbon	24040
R16	22k 5% 0.25W HS	Carbon	24041
R18	750 5% 0.25W HS	Carbon	24042
R19	33k 5% 0.25W HS	Carbon	24001
R24	3.6k 5% 0.25W HS	Carbon	24043
R25	4.7k 5% 0.25W HS	Carbon	24044
R26,27	47 5% 0.25W HS	Carbon	24045

* R1 ganged to switch S1; common part number 25002

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z5 - Pulse Shaper Type 77/310 (DRG. E68/94) (cont.)			
Transistors			
TR1,2	V405A	-	28205
TR3-5	BFY90	-	28204
TR6,7	U15718/2	-	28206
Integrated Circuits			
X1,2	SN7300N	-	28404
Z6 - STOP AND START SHAPERS TYPE 77/320 (DRG. E69/01)			
Capacitors			
C1,15	0.22µF 10% (250V)	Metallised film	26018
C2,14	47pF 5%	Ceramic	26019
C3,8,13	0.047µF +50% -25%	Polystyrene & Ceramic	26010
C4,5,11,12	47µF (6V)	Tantalum	26020
C6,7,9,10	100pF 5%	Ceramic	26021
C16	15µF (20V)	Tantalum	26017
Diodes			
D1,2	IN4009	-	28107
D3,4	U2973/2		28101
Resistors			
R1,32	20k 5% 0.25W HS	Carbon	24046
R2,30	18k 5% 0.25W HS	Carbon	24047
R3,5,16,17, 28,29	3.3k 5% 0.25W HS	Carbon	24048
R4,31	22k 5% 0.25W HS	Carbon	24041
R6,27,34	47 5% 0.25W HS	Carbon	24045
R7,26	510 5% 0.25W HS	Carbon	24049
R8-11,22-25	560 5% 0.25W HS	Carbon	24050
R12,21,35,36	470 5% 0.25W HS	Carbon	24051
R13,19	5.1k 5% 0.25W HS	Carbon	24052
R14,20	1k 5% 0.25W HS	Carbon	24033
R15,18	9.1k 5% 0.25W HS	Carbon	24028
R33	100 5% 0.25W HS	Carbon	24039
Transistors			
TR1*,8*	BC108	-	28201
TR2,3,6,7	V405A	-	28205
TR4,5	U1518/2	-	28206
Integrated Circuit			
X1	SN7413N	-	28405

* Gain not less than 71

Z7 - DIVIDER INTERFACE TYPE 77/400 (DRG. E68/100)

Capacitors			
C2	0.0047µF 10% (250V)	Metallised film	26022
C3,4,5	0.047µF +50% -25%	Polystyrene & Ceramic	26010
Diodes			
D1-16	U2973/2	-	28106

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z7 - Divider Interface Type 77/400 (DRG. E68/100)(cont.)			
Resistors			
R1,17	2.4k 5% 0.25W HS	Carbon	24053
R2,3,5,18	430 5% 0.25W HS	Carbon	24037
R4,25	2.2k 5% 0.25W HS	Carbon	24040
R6	2.7k 5% 0.25W HS	Carbon	24054
R7,9,15,20	3.3k 5% 0.25W HS	Carbon	24048
R8,10	9.1k 5% 0.25W HS	Carbon	24028
R11	8.2k 5% 0.25W HS	Carbon	24003
R12	7.5k 5% 0.25W HS	Carbon	24055
R13,16	1k 5% 0.25W HS	Carbon	24033
R14,22	3.9k 5% 0.25W HS	Carbon	24004
R19	1.5k 5% 0.25W HS	Carbon	24029
R21	15k 5% 0.25W HS	Carbon	24032
R23,26	4.7k 5% 0.25W HS	Carbon	24044
R24,27	10k 5% 0.25W HS	Carbon	24005
R28	820 5% 0.25W HS	Carbon	24056
Transistors			
TR1,2,4-9	U1518/2	-	28206
TR10	V405A	-	28205
Integrated Circuits			
X1,3	SN7400N	-	28406
X2	SN7490N	-	28407
Z8 - OSCILLATOR AND DIVIDER TYPE 77/500 (DRG. E69/02)			
Capacitors			
C1,2,3,13	0.047µF +50% -25%	Polystyrene & Ceramic	26010
C4,5	33µF (10V)	Tantalum	26013
C6	22pF 10%	Ceramic	26024
C7	0.22µF 10% (250V)	Metallised film	26018
C8	2-18pF	(Trimmer) Air spaced	26025
C9*	10pF (SIC)	Ceramic	26026
C10,11	6.8µF (6V)	Elect.Tantalum	26027
C12	56pF 5%	Ceramic	26028
Diodes			
D1-5	U2973/2	-	28106
D6	IN4009	-	28108
D7	BZY88/C6V2	-	28371-483
Resistors			
R1,2,15,18	3.3k 5% 0.125W	Carbon film	24057
R3,4,6,7, 19,28	10k 5% 0.125W	Carbon film	24058
R5	1k 5% 0.25W HS	Carbon	24033
R8-10	100k 5% 0.125W	Carbon film	24059
R11	10 5% 0.125W	Carbon film	24013
R12,13	8.2k 5% 0.125W	Carbon film	24060
R14	47 5% 0.25W HS	Carbon	24045
R16	18k 5% 0.125W	Carbon film	24026
R17	22k 5% 0.125W	Carbon film	24061
R20	2.4k 5% 0.25W HS	Carbon	24053
R21	560 5% 0.25W HS	Carbon	24050
R22	3.6k 5% 0.25W HS	Carbon	24043

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z8 - Oscillator and Divider Type 77/500 (DRG. E69/02)(cont.)			
Resistors(cont.)			
R23	180 5% 0.25W HS	Carbon	24062
R24	75 5% 0.25W HS	Carbon	24063
R25	7.5k 5% 0.25W HS	Carbon	24055
R26	470 5% 0.125W	Carbon film	24027
R27,29,32	3.9k 5% 0.125W	Carbon film	24064
R30	12k 5% 0.125W	Carbon film	24065
R31	330 5% 0.25W HS	Carbon	24066
Transistors			
TR1,2,3,4,5	U1518/2	-	28206
TR2+	BC108	-	28201
Integrated Circuits			
X1,2	C16	-	28408
X3	SN7413N	-	28405
X4	SN7400N	-	28406
Crystal			
XTL1	10MHz	Glass style L	28301

* For crystals (XTL1) colour codes with a red mark the value of C9 is 100pF or 120pF as determined on test.

\+ Gain not less than 71

Note - for TF 2416/1 and TF 2416/2 see TYPE 77/510 and TYPE 77/511 stock lists

Z9 - OSCILLATOR AND DIVIDER TYPES 77/510 AND 77/511 (DRG. E69/22)

NOTE These cards are used only on the TF 2416/2 and TF 2416/1 respectively. Components and values are applicable to both types of card except where otherwise marked.

Capacitors			
C1	56pF 5%	Ceramic	26028
C2,3,9,11	0.047μF +50% -25%	Polystyrene & Ceramic	26010
C4,5	33μF (10V)	Tantalum	26013
C6,7	6.8μF (6V)	Elect. Tantalum	26027
C8	22pF 10%	Ceramic	26024
C10	0.22μF 10% (250V)	Metallised film	26018
Diodes			
D1-5	U2973/2	-	28106
D6	IN4009	-	28108
Plugs (Card type 77/510 only)			
PL1	Black	-	23005
PL2	Red	-	23006
PL3	Green	-	23007

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z9 - Oscillator and Divider Types 77/510 and 77/511 (cont.)			
Resistors			
R1,5,8	3.9k 5% 0.125W	Carbon film	24064
R2,3,22,24	3.3k 5% 0.125W	Carbon film	24057
R4,6,7,10, 11,26	10k 5% 0.125W	Carbon film	24058
R9	1k 5% 0.25W HS	Carbon	24033
R12-14	100k 5% 0.125W	Carbon film	24054
R15 Card type 77/510:	22 5% 0.125W	Carbon film	24067
Card type 77/511:	1.5k 5% 0.125W	Carbon film	24024
R16	4.3k 5% 0.25W HS	Carbon	24030
R17	4.7k 5% 0.25W HS	Carbon	24044
R18,20	8.2k 5% 0.25W HS	Carbon	24003
R19	330 5% 0.25W HS	Carbon	24066
R21	47 5% 0.125W	Carbon film	24025
R23	18k 5% 0.125W	Carbon film	24026
R25	12k 5% 0.125W	Carbon film	24065
R27	470 5% 0.125W	Carbon film	24027
R28	22k 5% 0.125W	Carbon film	24061
Sockets (Card type 77/510 only)			
SK1-3	50S/PCB	-	23004
Transistors			
TR1,2	U1518/2	-	28206
TR3	BC108	-	28201
Integrated Circuits			
X1,2	C16	-	28408
X3	SN7413N	-	28405
X4	SN7400N	-	28406
Oscillators			
X5	Card type 77/510: 3181-01	10MHz	28302
	Card type 77/511: QC1223	10MHz	28303
Z10 - GATE, CONTROL AND RESET TYPE 77/600 (DRG. E68/99)			
Capacitors			
C1	0.047µF 10% (250V)	Metallised film	26029
C2	15µF (20V)	Tantalum	26017
C3	0.068µF 10% (250V)	Metallised film	26030
C5	2.2µF (20V)	Tantalum	26015
C6,10	0.0047µF 10% (250V)	Metallised film	26022
C7*	10pF (SIC)	Ceramic	26026
C8*,9	0.1µF (SIC)(250V)	Metallised film	26031
C11,17,18	0.047µF +50% -25%	Polystyrene & Ceramic	26010
C12	33µF (10V)	Tantalum	26016
C13,14	1000pF 10%	Ceramic	26032
C19	47pF 5%	Ceramic	26019
Diodes			
D1,2,3*,4,5 8-15	U2973/2	-	28106
D6,7	1N4009	-	28108

* Fitted only for Ext. Reset Input facility

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z10 - Gate, Control and Reset Type 77/600 (DRG. E68/99)(cont.)			
Resistors			
R1	3.9k 5% 0.25W HS	Carbon	24004
R2	5.6k 5% 0.25W HS	Carbon	24068
R3,16	4.7k 5% 0.25W HS	Carbon	24044
R4,10,11, 12*,13*,17	10k 5% 0.25W HS	Carbon	24005
R5	47 5% 0.25W HS	Carbon	24045
R6,25,27,37	9.1k 5% 0.25W HS	Carbon	24028
R7	12k 5% 0.25W HS	Carbon	24069
R8	47k 5% 0.25W HS	Carbon	24070
R9*,18,34, 36,31	1k 5% 0.25W HS	Carbon	24033
R14	5.1k 5% 0.25W HS	Carbon	24052
R15	22k 5% 0.25W HS	Carbon	24041
R19	8.2k 5% 0.25W HS	Carbon	24003
R20	7.5k 5% 0.25W HS	Carbon	24055
R21,30	6.8k 5% 0.25W HS	Carbon	24071
R22,26,28, 38	3.3k 5% 0.25W HS	Carbon	24048
R23,35	10 5% 0.25W HS	Carbon	24036
R24	470 5% 0.25W HS	Carbon	24051
R29,32	100 5% 0.25W HS	Carbon	24039
R33	2.2k 5% 0.25W HS	Carbon	24040
Transistors			
TR1	V435	-	28207
TR2,3	BC108	-	28201
TR4,5	U1518/2	-	28206
TR6	V405A	-	28205
Integrated Circuits			
X1	SN7400N	-	28406
X2	SN7473N	-	28409
X3	SN7401N	-	28410
* Fitted only for Ext. Reset Input facility			
Z11 - COUNTER TYPE 77/700 (DRG. E68/98)			
Capacitors			
C1,2,(5-10)	0.047µF +50% -25%	Polystyrene & Ceramic	26010
C3	22pF 10%	Ceramic	26024
C4	56pF 5%	Ceramic	26028
Diodes			
D1-4	U2973/2	-	28106
D5-10	U2973/2	-	28101
Resistors			
R1-4	12k 5% 0.25W HS	Carbon	24009
R5-8	2.7k 5% 0.25W HS	Carbon	24054
R9,10,16-19	10 5% 0.25W HS	Carbon	24036
R11,15	1k 5% 0.25W HS	Carbon	24033
R12	22k 5% 0.25W HS	Carbon	24041
R13	470 5% 0.25W HS	Carbon	24051
R14	680 5% 0.25W HS	Carbon	24072

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z11 - Counter Type 77/700 (DRG. E68/98) (cont.)			
Transistors			
TR1,2	U1518/2	-	28206
Integrated Circuits			
X1	SN74196N	-	28411
X2	SN7475N	-	28412
X3	C16 (with red spot) ✓	-	28413
X4,5	C16	-	28408

Z12 - NOT ALLOCATED

Circuit Reference	Type	Description	Marconi Part No. (TF 2416/FPP ...)
Z13 - DISPLAY TYPE 77/807 (DRG. E68/96)			
Capacitors			
C1	0.01μF 10% (250V)	Metallised film	26033
C2	0.1μF (SIC) (250V)	Metallised film	26031
C3	0.22μF 10% (250V)	Metallised film	26018
C4	560pF 10%	Ceramic	26034
C5	0.01μF +50% -25%	Polystyrene & Ceramic	26035
C6	1500pF 10%	Ceramic	26036
Diodes			
D1	U2973/2	-	28101
D2-8	MZ92/91B	-	28109
Resistors			
R1	180k 5% 0.25W HS	Carbon	24074
R2	1M 5% 0.25W HS	Carbon	24031
R3	100k 5% 0.25W HS	Carbon	24007
R4	270k 5% 0.25W HS	Carbon	24075
R5,7,9,11, 13,15,17	75k 5% 0.25W HS	Carbon	24076
R19,20	18k 5% 1W	Metal oxide	24077
R21	47k 5% 0.25W HS	Carbon	24070
R22	1k 5% 0.25W HS	Carbon	24033
R23	12k 5% 0.25W HS	Carbon	24009
R24	1k 5% 0.25W HS	Carbon	24033
R25-28	22k 5% 0.25W HS	Carbon	24041
Transistors			
TR1-7,9*	C407	-	28202
TR8*	BC108	-	28201
Indicators			
V1	16L	Neon Lamp	23702
V2-8	-	Numicator tube	28001
Integrated Circuit			
X1	CμL9960	-	28416

* Fitted only for BCD output

Z14 - DISPLAY CONTROL TYPE 77/817 (DRG. E68/97)			
Capacitors			
C(1-7)	0.047μF +50% -25%	Polystyrene & Ceramic	26010
Diodes			
D(1-7)	BYX10	-	28110
D8	U2973/2	-	28106
Resistors			
R1,5,9,13, 17,21,25	12k 5% 0.25W HS	Carbon	24009
R2,6,10,14, 18,22,26	430 5% 0.25W HS	Carbon	24037
R3,7,11,15, 19,23,27	680 5% 0.25W HS	Carbon	24072
R4,8,12,16, 20,24,28	180k 5% 0.25W HS	Carbon	24074
Transistors			
TR(1-7)	C407	-	28202
TR8,9	BC108	-	28201

Circuit Reference	Type				Description	Marconi Part No. (TF 2416/FPP ...)
Z15 - SERIAL B.C.D. INTERFACE TYPE 77/910 (DRG. E69/33) (TF 2416/3 only)						
Capacitors						
C1	SN74L164N					28417
C2	SN74L73N					28418
Resistors						
R1	1.5k	5%	0.25W	HS	Carbon	24029
R2,7	2.7k	10%	0.33W		Min. Carbon film	24073
R3,4	5.6k	10%	0.33W		Min. Carbon film	24078
R5	1k	5%	0.25W	HS	Carbon	24033
R6,9	1k	5%	0.33W		Min. Carbon film	24079
R8	4.7k	10%	0.33W		Min. Carbon film	24080
R10	1.5k	10%	0.33W		Min. Carbon film	24024
R11,13,15,17	27k	5%	0.25W	HS	Carbon	24081
R12,14,16,18	8.2k	10%	0.33W		Min. Carbon film	24060
Transistors						
TR(1-3)	U1518/2					28206
TR(4-7)	BC108					28201
Integrated Circuits						
X(1-4)	SN74L164N					28417
X5	SN74L73N					28418
Z16 - PARALLEL B.C.D. INTERFACE TYPE 77/900 (DRG. E69/27) (TF 2416/4 only)						
Resistors						
R(1-4)	8.2k	5%	0.25W	HS	Carbon	24003
R(5-8)	27k	5%	0.25W	HS	Carbon	24081
Transistors						
TR(1-4)	BC108					28201

Chapter 7

Circuit diagrams

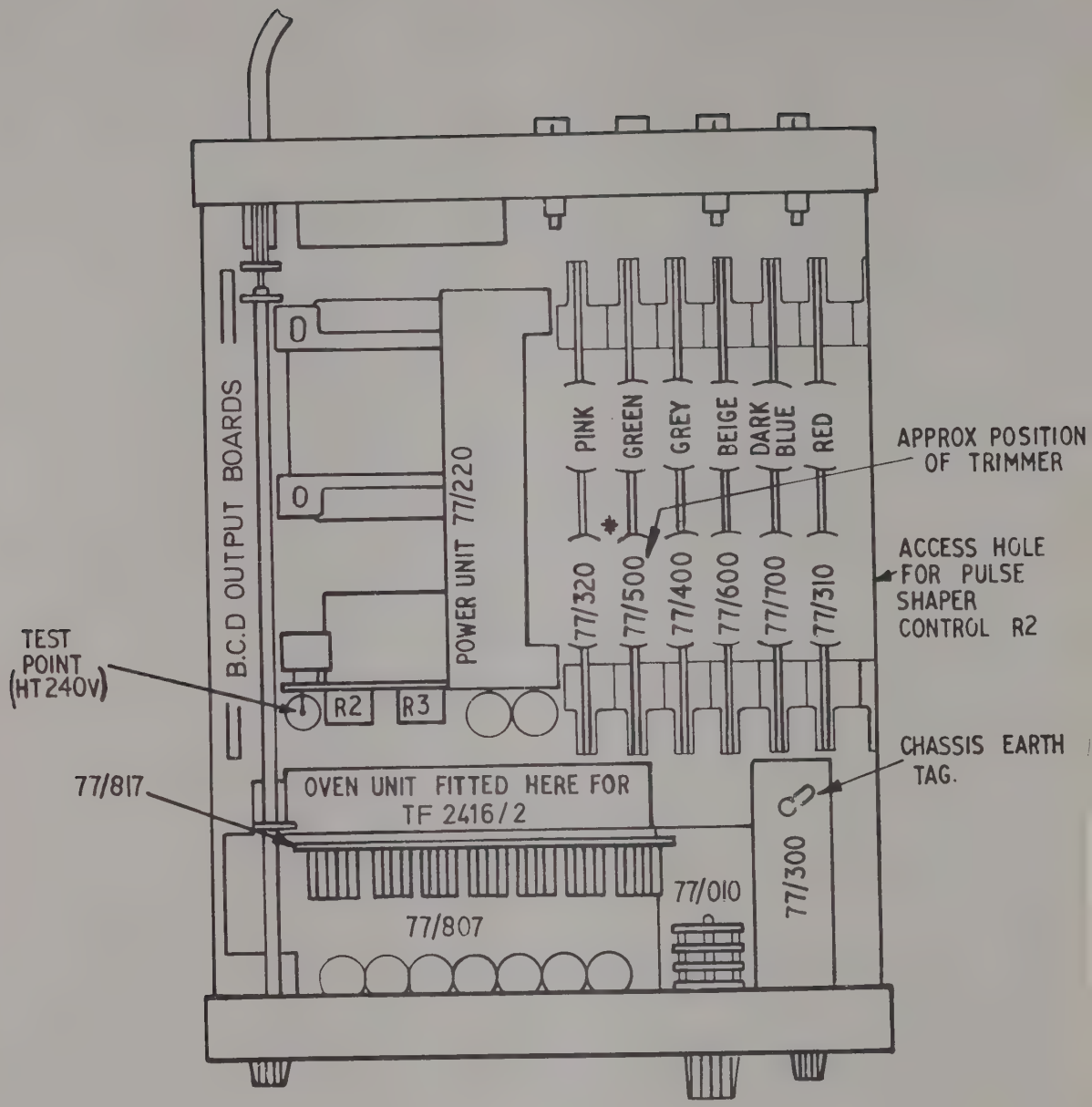
The Circuit Diagrams are in numerical order of their Type numbers (e.g. Type 77/010) and not in order of their Circuit Diagram numbers (e.g. E68/91).

Where applicable Board Layout Diagrams, also designated with the Type number prefixed by BL (e.g. BL77/010), are positioned on the left-hand page thus facing the appropriate circuit diagram on the right-hand page.

The Board Layout diagrams and Circuit diagrams are in the order as indicated below:-

TF 2416 Series	Board Layout Plan	S69/84
TF 2416	SIGNAL PATH DIAGRAM	E69/25
TF 2416	FUNCTIONAL CONTROL BLOCK SCHEMATIC	E69/26
BL77/010 TYPE 77/010	Switch Board Layout FRONT PANEL ASSEMBLY CIRCUIT	E68/91
TYPE 77/020	REAR PANEL ASSEMBLY CIRCUIT	E68/93
BL77/220 TYPE 77/220	Power Supply Board Layout POWER SUPPLY CIRCUIT	E68/92
BL77/300 TYPE 77/300	Pre-Amp Board Layout PRE-AMP CIRCUIT	E68/95
BL77/310 TYPE 77/310	Pulse Shaper Layout PULSE SHAPER CIRCUIT	E68/94
BL77/320 TYPE 77/320	Stop & Start Shapers Layout STOP & START SHAPERS CIRCUIT	E69/01
BL77/400 TYPE 77/400	Divider Interface Layout DIVIDER INTERFACE CIRCUIT	E68/100
BL77/500 TYPE 77/500	Oscillator & Divider Layout OSCILLATOR & DIVIDER CIRCUIT	E69/02
BL77/510 & 77/511 TYPE 77/510 & 77/511	Oscillator & Divider Layout (TF 2416/2 & TF2416/1) OSCILLATOR & DIVIDER CIRCUIT (TF2416/2 &TF2416/1)	E69/22
BL77/600 TYPE 77/600	Gate Control & Reset Layout GATE CONTROL & RESET CIRCUIT	E68/99
TYPE 77/700,77/807 & 77/817	COUNTER & SCANNING DISPLAY CIRCUIT	E69/24
BL77/700 TYPE 77/700	Counter Layout COUNTER CIRCUIT	E68/98

BL77/807 TYPE 77/807	Display Layout DISPLAY CIRCUIT	E68/96
BL77/817 TYPE 77/817	Display Control Layout DISPLAY CONTROL CIRCUIT	E68/97
BL77/900 TYPE 77/900	Parallel BCD Interface Layout (TF 2416/4) PARALLEL BCD INTERFACE CIRCUIT(TF 2416/4)	E69/27
BL77/910 TYPE 77/910	Serial BCD Interface Layout (TF 2416/3) SERIAL BCD INTERFACE CIRCUIT	E69/33



* OR CARD: TYPE 77/511 (TF2416/1)
TYPE 77/510 (TF2416/2)

NOTE: NOT TO SCALE.
NOT ALL COMPONENTS ARE SHOWN.

COUNTER/TIMER

BOARD LAYOUT PLAN

TF 2416 Series

Drg. No. S69/84

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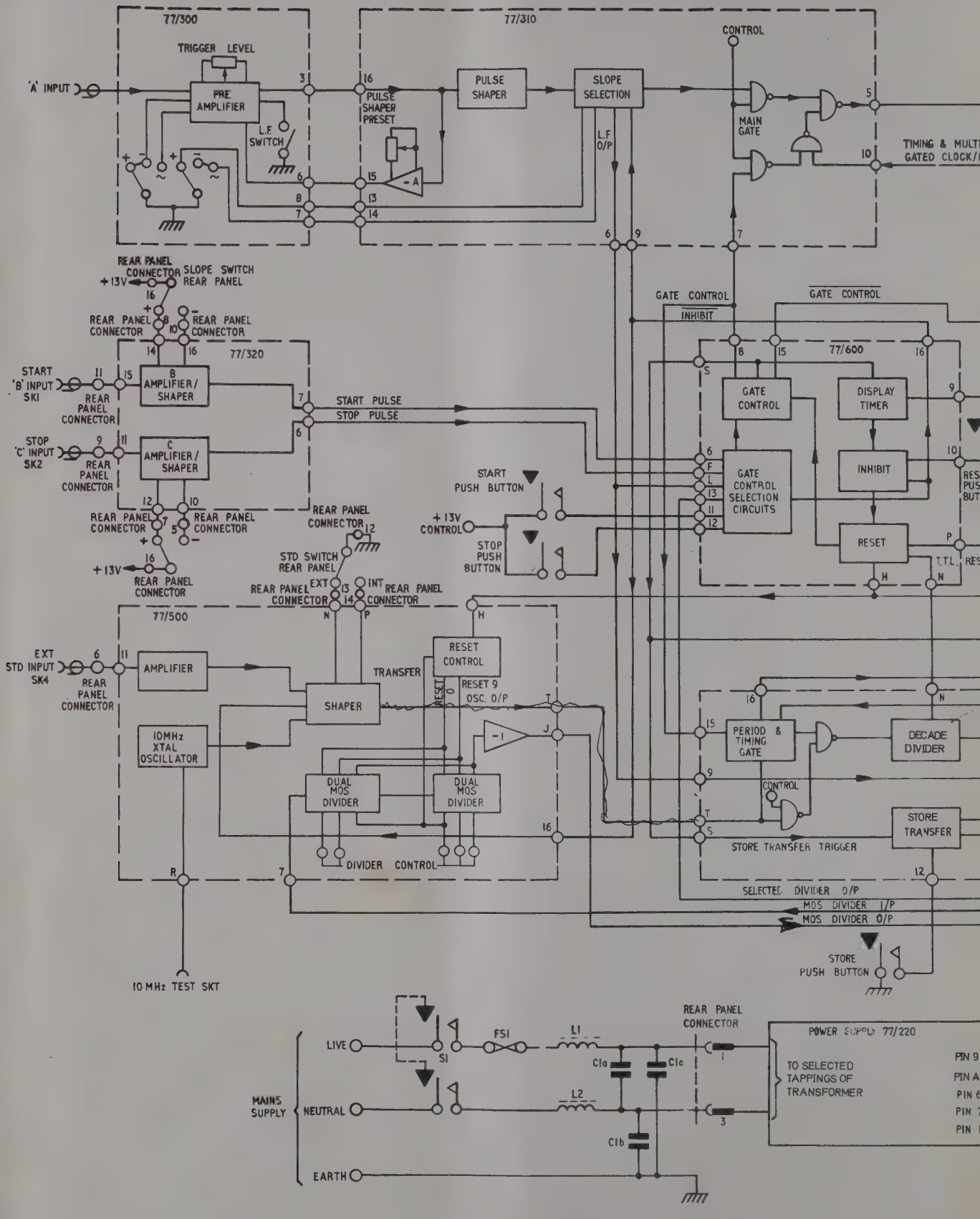
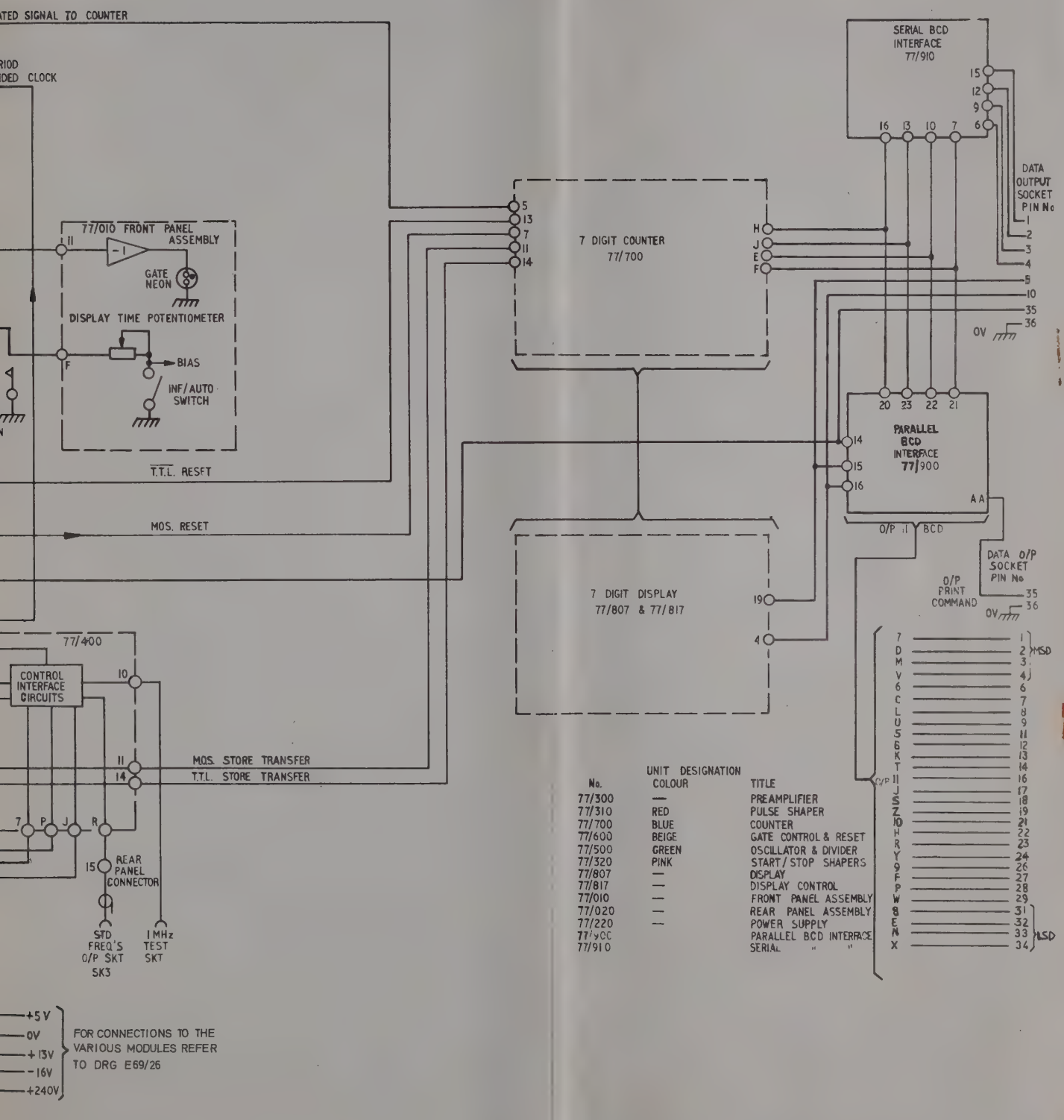
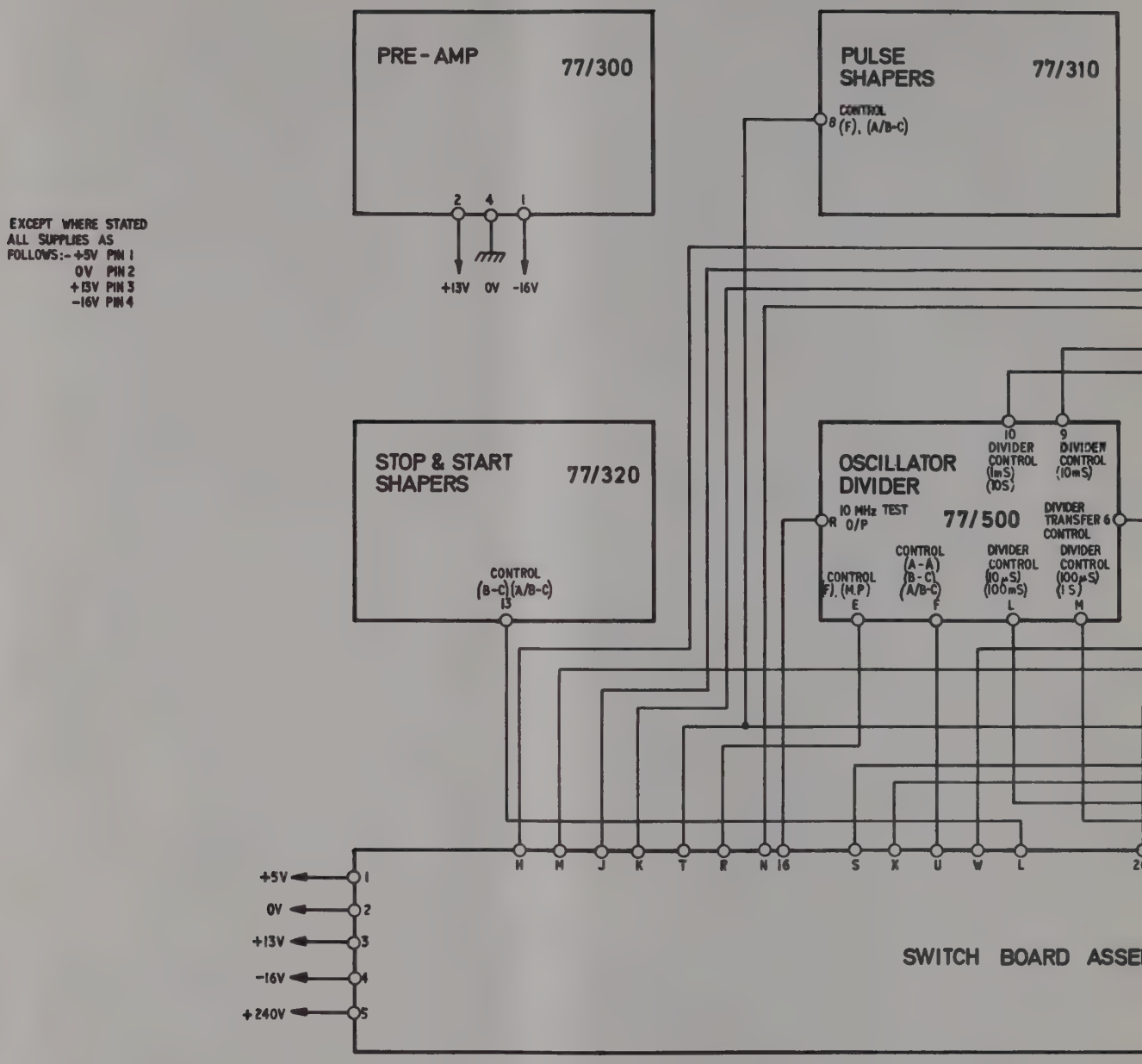

77/300
TRIGGER LEVEL
'A' INPUT
PRE AMPLIFIER
L.F. SWITCH
77/310
PULSE SHAPER PRESET
PULSE SHAPER
SLOPE SELECTION
L.F. O/P
CONTROL
MAIN GATE
TIMING & MULT
GATED CLOCK/
REAR PANEL CONNECTOR
+13V
SLOPE SWITCH REAR PANEL
REAR PANEL CONNECTOR
REAR PANEL CONNECTOR
77/320
START 'B' INPUT SK1
B AMPLIFIER / SHAPER
REAR PANEL CONNECTOR
START PULSE
STOP PULSE
STOP 'C' INPUT SK2
C AMPLIFIER / SHAPER
REAR PANEL CONNECTOR
REAR PANEL CONNECTOR
REAR PANEL CONNECTOR
REAR PANEL CONNECTOR
+13V
REAR PANEL CONNECTOR
START PUSH BUTTON
+13V CONTROL
STOP PUSH BUTTON
STD SWITCH REAR PANEL
REAR PANEL CONNECTOR
EXT
INT
REAR PANEL CONNECTOR
GATE CONTROL
INHIBIT
GATE CONTROL
77/600
GATE CONTROL
DISPLAY TIMER
INHIBIT
GATE CONTROL SELECTION CIRCUITS
RESET
T.T.L.
77/500
EXT STD INPUT SK4
REAR PANEL CONNECTOR
AMPLIFIER
SHAPER
TRANSFER
RESET CONTROL
RESET 9
RESET 0
OSC. O/P
10MHz XTAL OSCILLATOR
DUAL MOS DIVIDER
DUAL MOS DIVIDER
DIVIDER CONTROL
10 MHz TEST SKT
PERIOD & TIMING GATE
DECADE DIVIDER
CONTROL
STORE TRANSFER
STORE TRANSFER TRIGGER
SELECTED DIVIDER O/P
MOS DIVIDER I/P
MOS DIVIDER O/P
STORE PUSH BUTTON
REAR PANEL CONNECTOR
POWER SUPPLY 77/220
LIVE
NEUTRAL
EARTH
MAINS SUPPLY
SI
FSI
L1
L2
C1a
C1c
C1b
TO SELECTED TAPPINGS OF TRANSFORMER
PIN 9
PIN A
PIN 6

NOTE. CARD TYPE 77/900 FITTED ONLY FOR OPTION Z.
CARD TYPE 77/910 FITTED ONLY FOR OPTION Y.

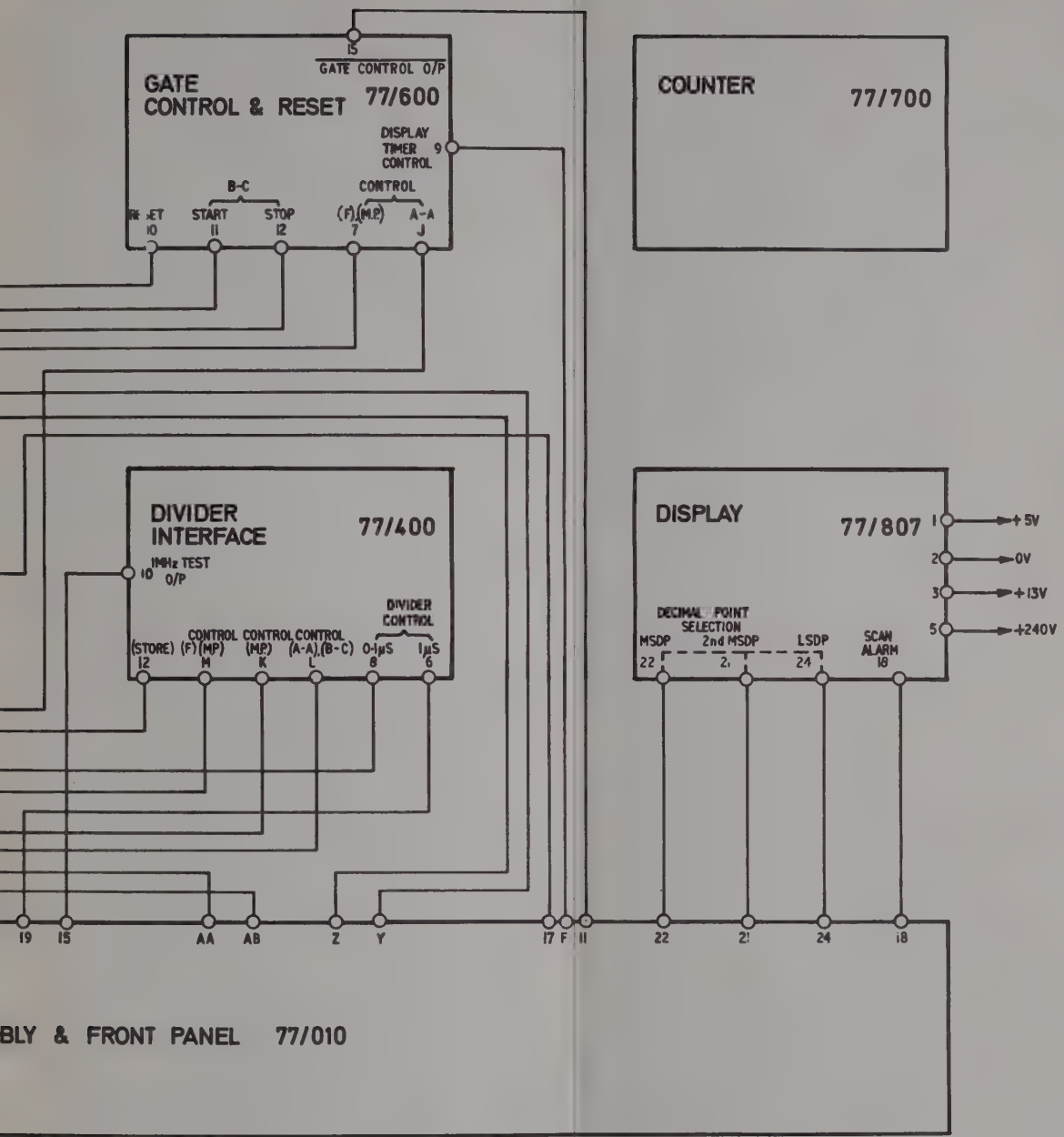


No.	UNIT DESIGNATION COLOUR	TITLE
77/300	—	PREAMPLIFIER
77/310	RED	PULSE SHAPER
77/700	BLUE	COUNTER
77/600	BEIGE	GATE CONTROL & RESET
77/500	GREEN	OSCILLATOR & DIVIDER
77/320	PINK	START/STOP SHAPERS
77/807	—	DISPLAY
77/817	—	DISPLAY CONTROL
77/010	—	FRONT PANEL ASSEMBLY
77/020	—	REAR PANEL ASSEMBLY
77/220	—	POWER SUPPLY
77/900		PARALLEL BCD INTERFACE
77/910		SERIAL " "

SIGNAL PATH DIAGRAM
TF 2416
DRG. NO. E69/25



ABBREVIATIONS USED
(F) = FREQUENCY
(M.P) = MULTIPERIOD
(A-A) = TIMING (A-A)
(B-C) = TIMING (B-C)
(A/B-C) = COUNT (A/B-C)
MSDP = MOST SIGNIFICANT DECIMAL POINT
LSDP = LEAST " " "

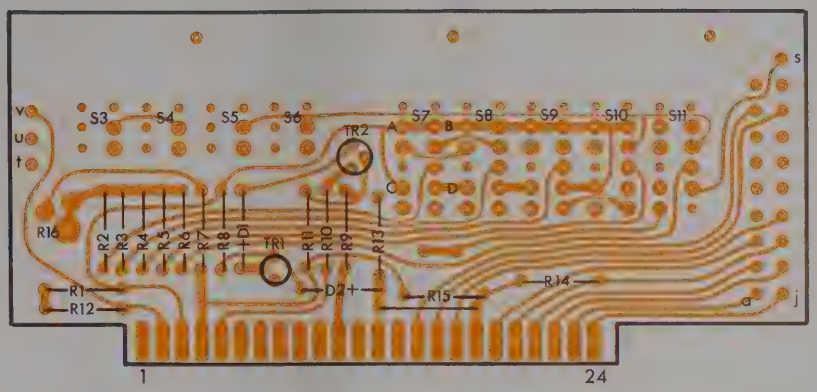


FUNCTION CONTROL

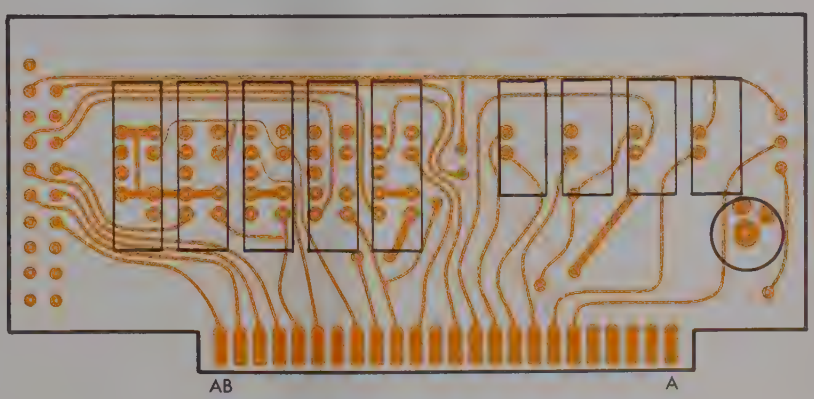
BLOCK SCHEMATIC DIAGRAM

TF 2416

DRG. NO. E69/26



VIEWED FROM NON- COMPONENT SIDE.



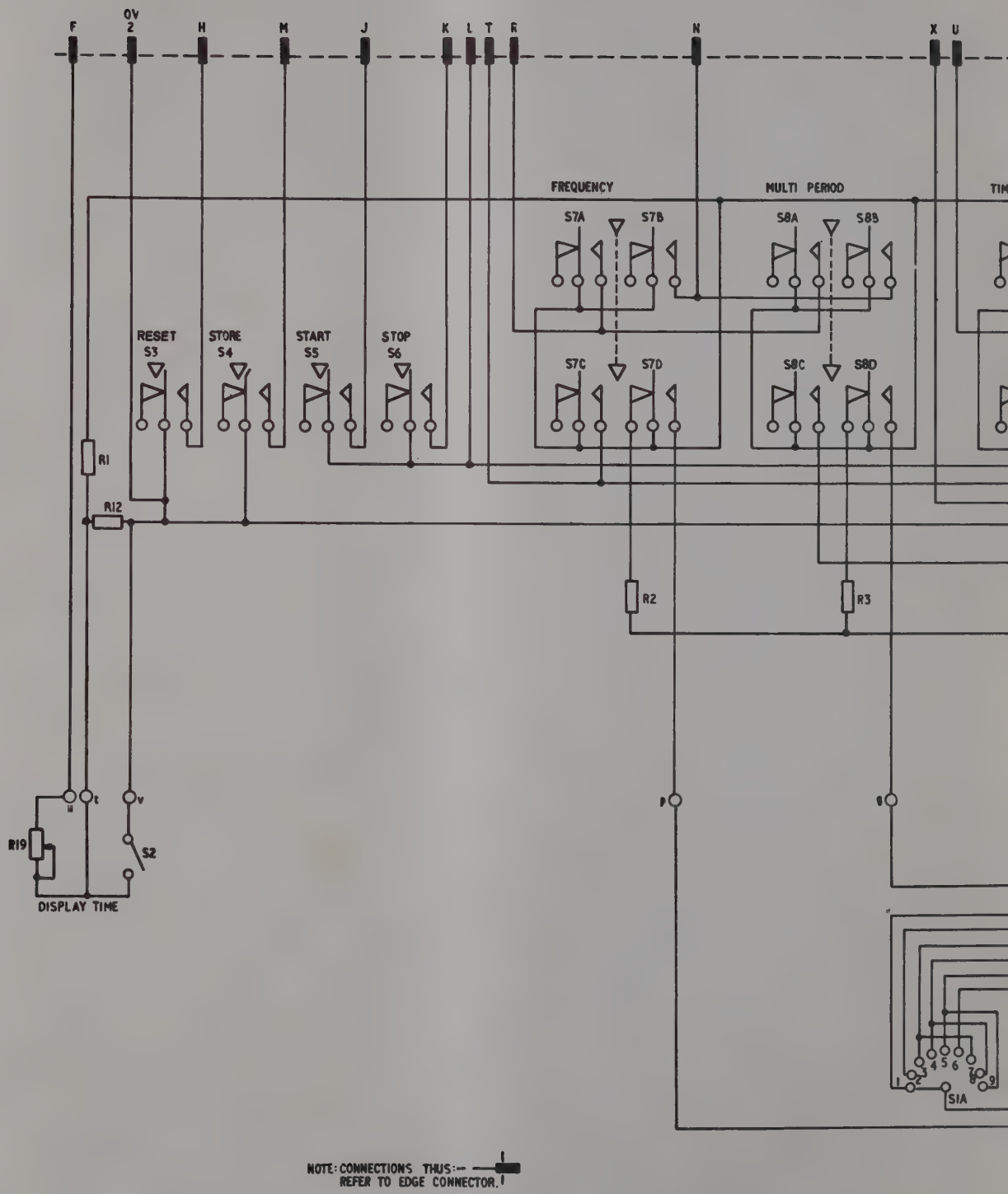
VIEWED FROM COMPONENT SIDE.

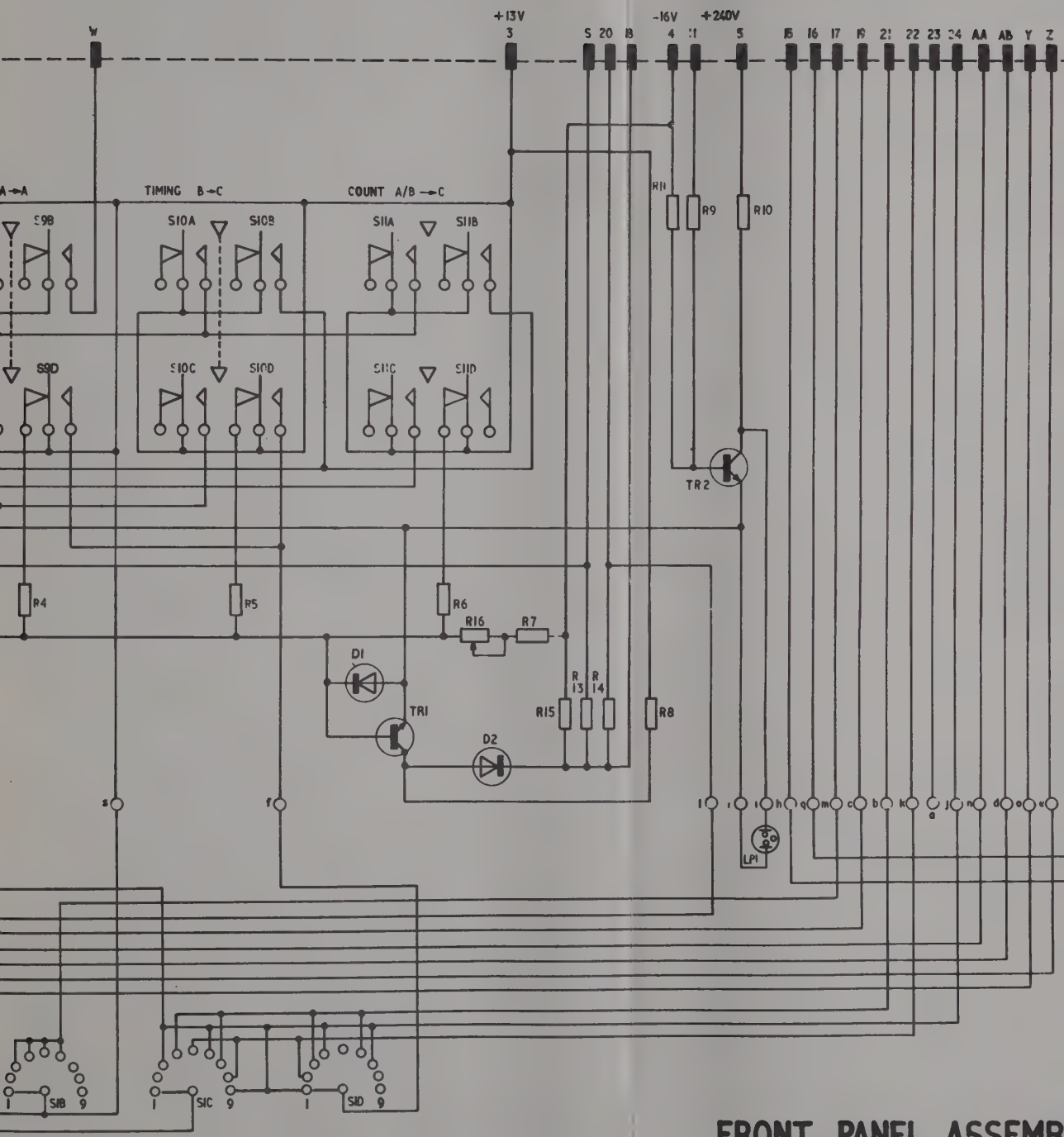
SCALE 3/4 FULL SIZE.

SWITCH BOARD

TYPE 77/010

BL 77/010


F
0V
2
H
M
J
K
L
T
R
N
X
U
FREQUENCY
MULTI PERIOD
S7A
S7B
S8A
S8B
S7C
S7D
S8C
S8D
RESET
S3
STORE
S4
START
S5
STOP
S6
R1
R12
R2
R3
R19
S2
DISPLAY TIME
S1A
NOTE: CONNECTIONS THUS:-
REFER TO EDGE CONNECTOR.

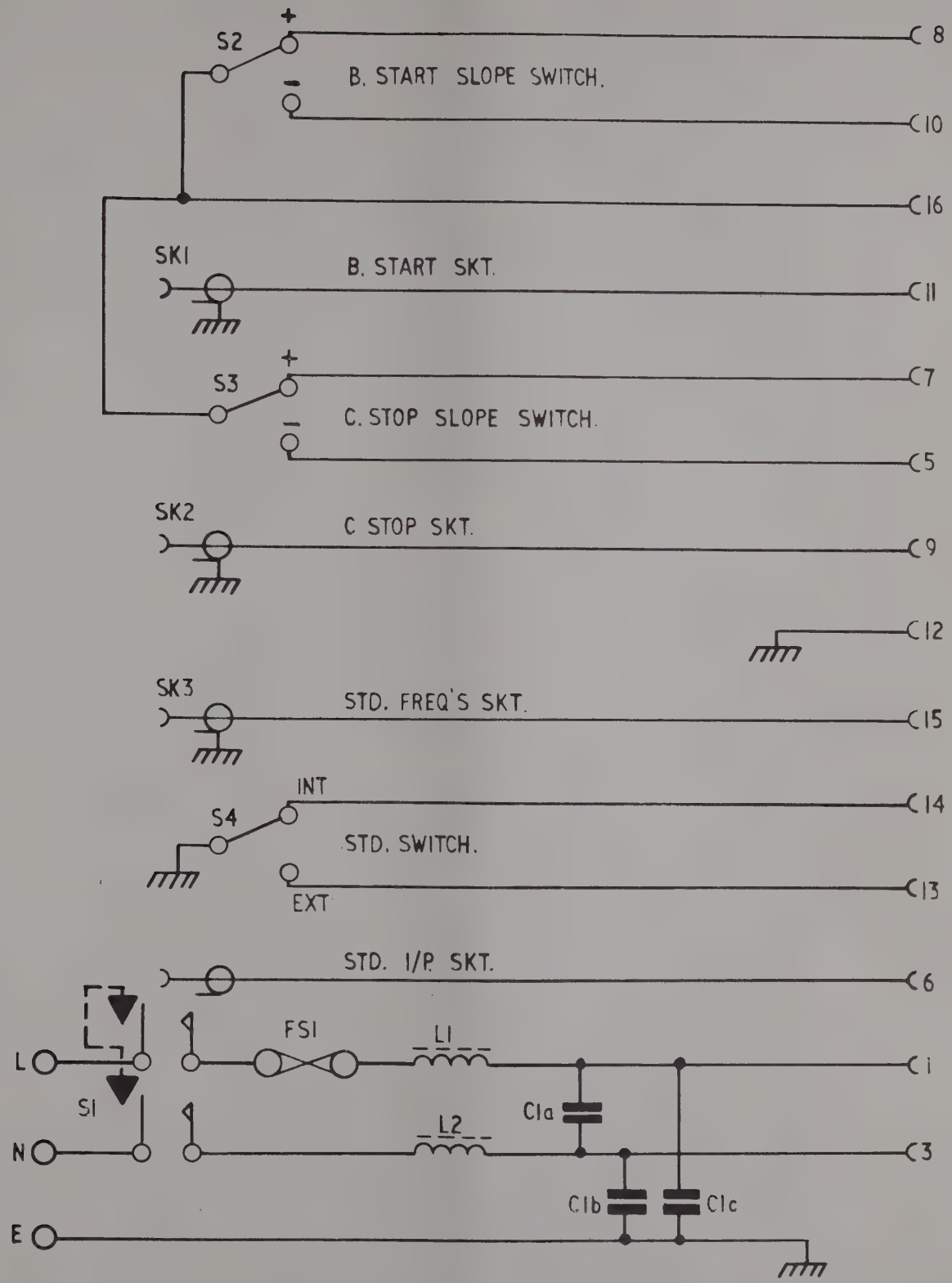


FRONT PANEL ASSEMB

CIRCUIT DIAGRAM

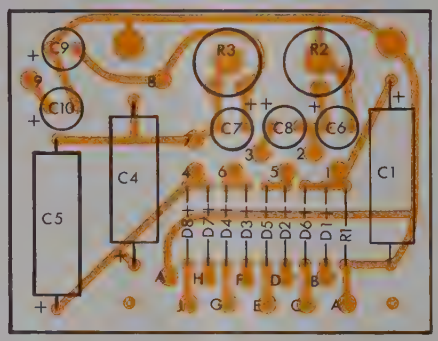
Type 77/010

DRG. NO. E68/91



REAR PANEL
CIRCUIT DIAGRAM
Type 77/020
DRG. NO. E68/93

MARCONI INSTRUMENTS LTD TF 2416



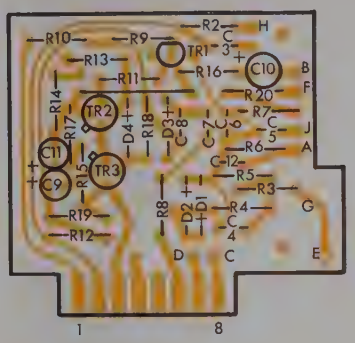
VIEWED FROM NON-COMPONENT SIDE.

SCALE 3/4 FULL SIZE.

POWER SUPPLY

TYPE 77/220

BL 77/220



VIEWED FROM NON-COMPONENT SIDE.

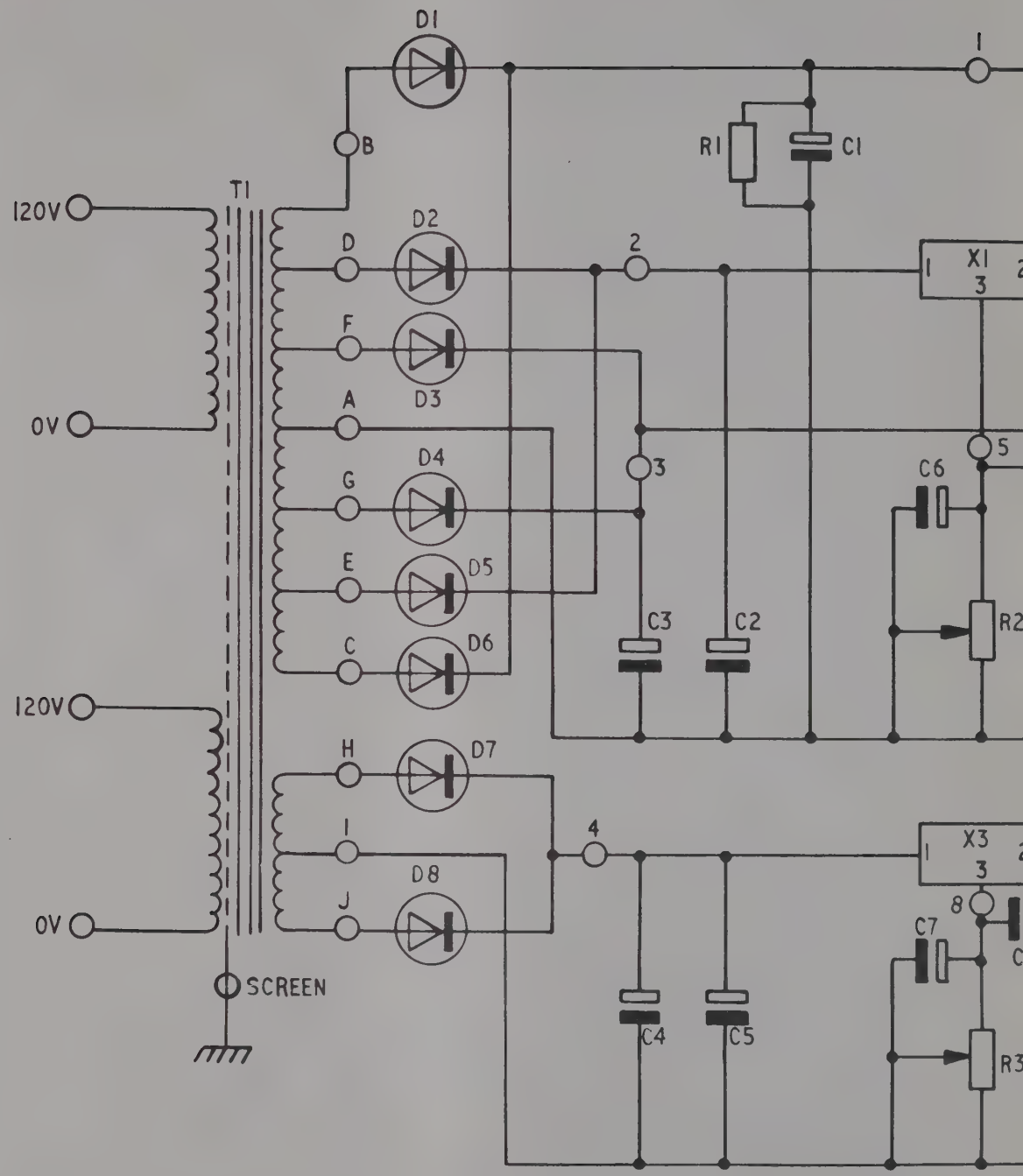
VIEWED FROM COMPONENT SIDE

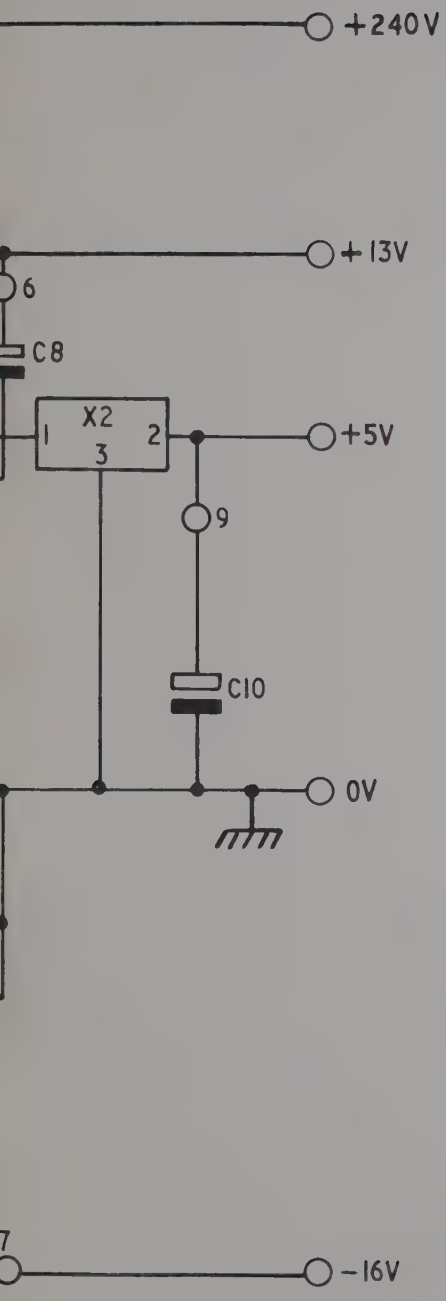
SCALE 3/4 FULL SIZE.

PRE-AMP.

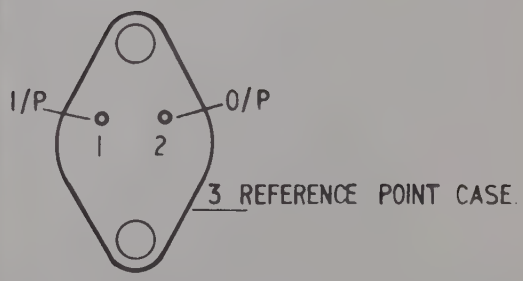
TYPE 77/300

BL 77/300


D1
B
R1
C1
1
T1
120V
0V
D
D2
2
X1
3
F
D3
A
3
5
D4
G
C6
E
D5
C3
C2
R2
C
D6
120V
H
D7
4
X3
3
I
8
D8
J
C7
0V
SCREEN
C4
C5
R3



PIN CONNECTION	SECONDARY O/P
B	207V
D	18V
F	9·5V
A	0V
G	9·5V
E	18V
C	207V
H	22V
I	0V
J	22V



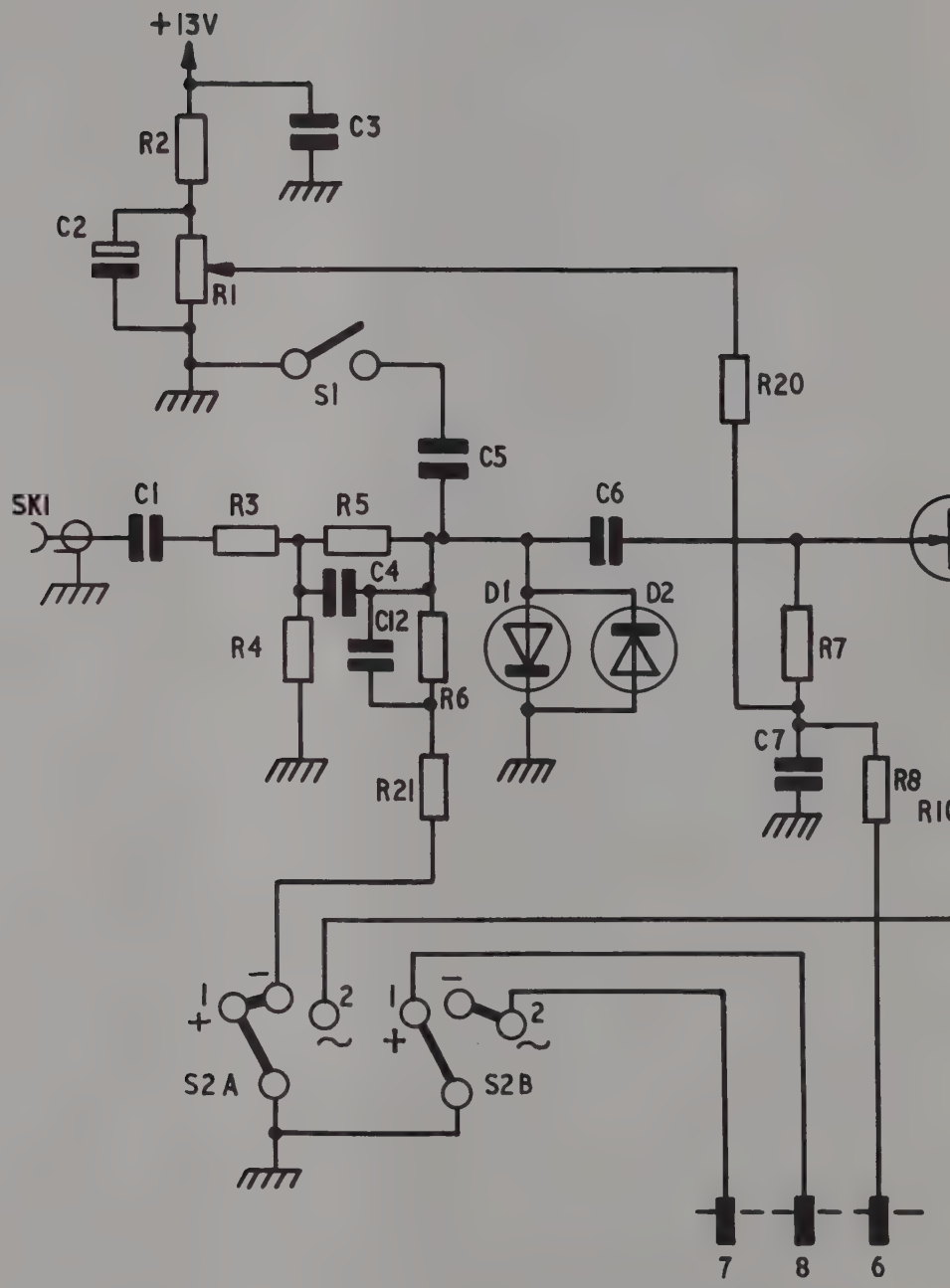
VIEWED FROM UNDERSIDE

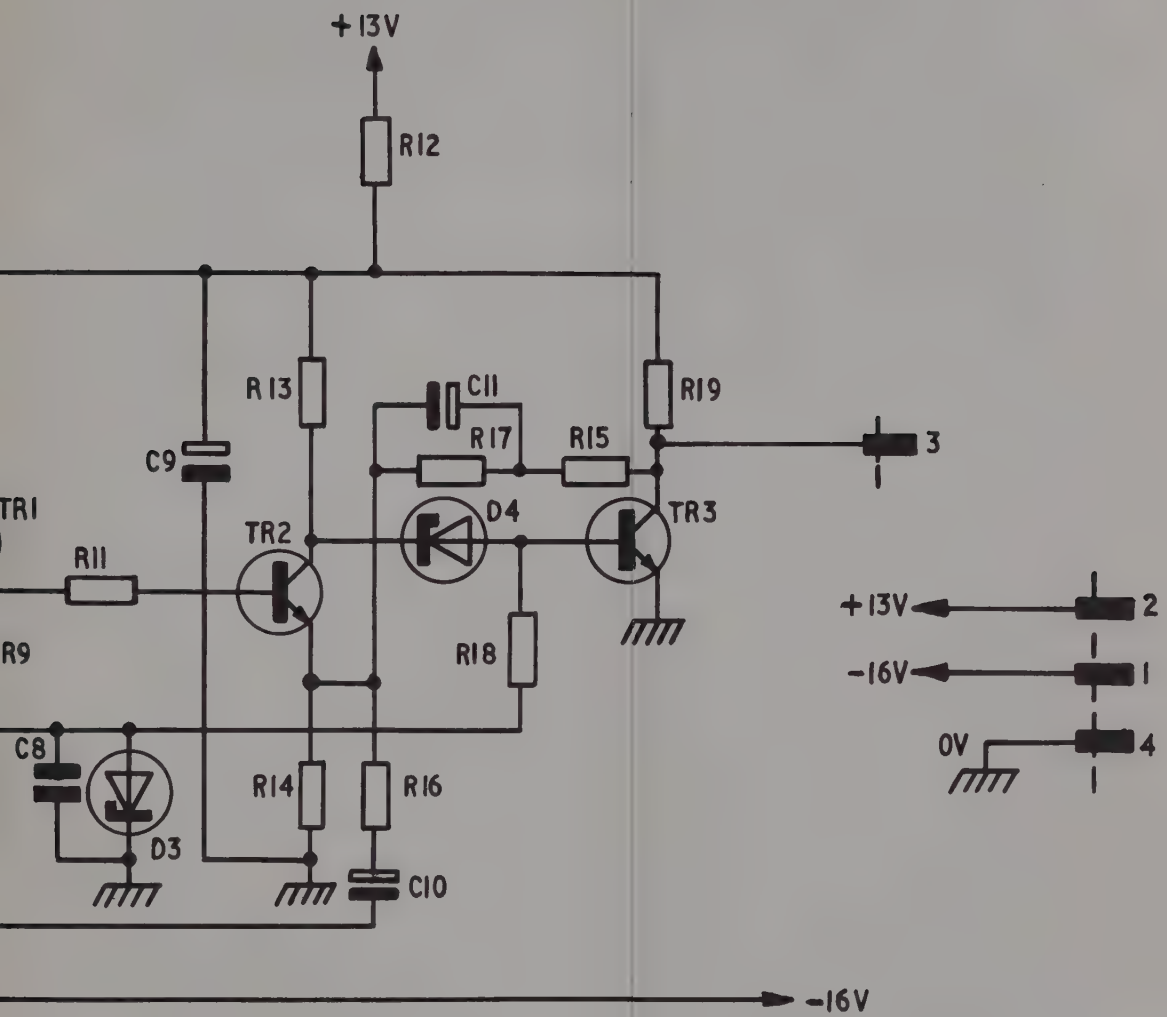
POWER SUPPLY

CIRCUIT DIAGRAM

Type 77/220

DRG. NO. E68/92


+13V
R2
C3
C2
R1
S1
R20
C5
SKI
C1
R3
R5
C6
C4
D1
D2
C12
R4
R7
R6
C7
R8
R21
S2A
S2B
7
8
6



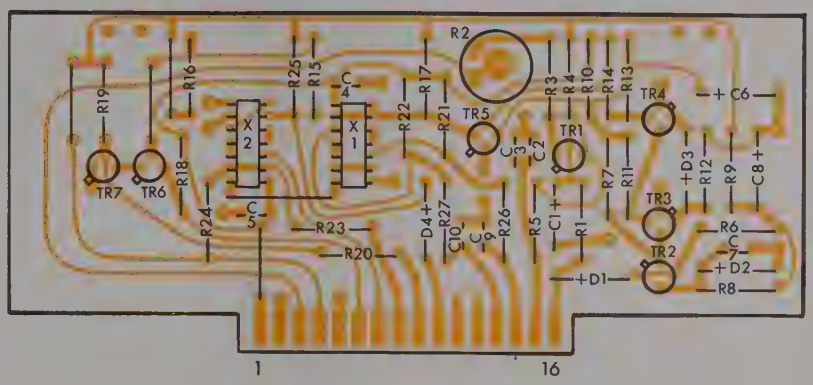
CONNECTIONS THUS:- —— REFER TO EDGE CONNECTOR.

PRE AMP

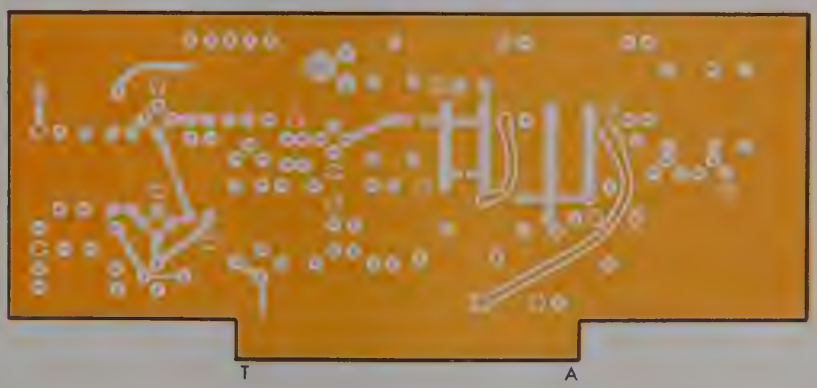
CIRCUIT DIAGRAM

Type 77/300

DRG. No. E68/95



VIEWED FROM NON-COMPONENT SIDE.



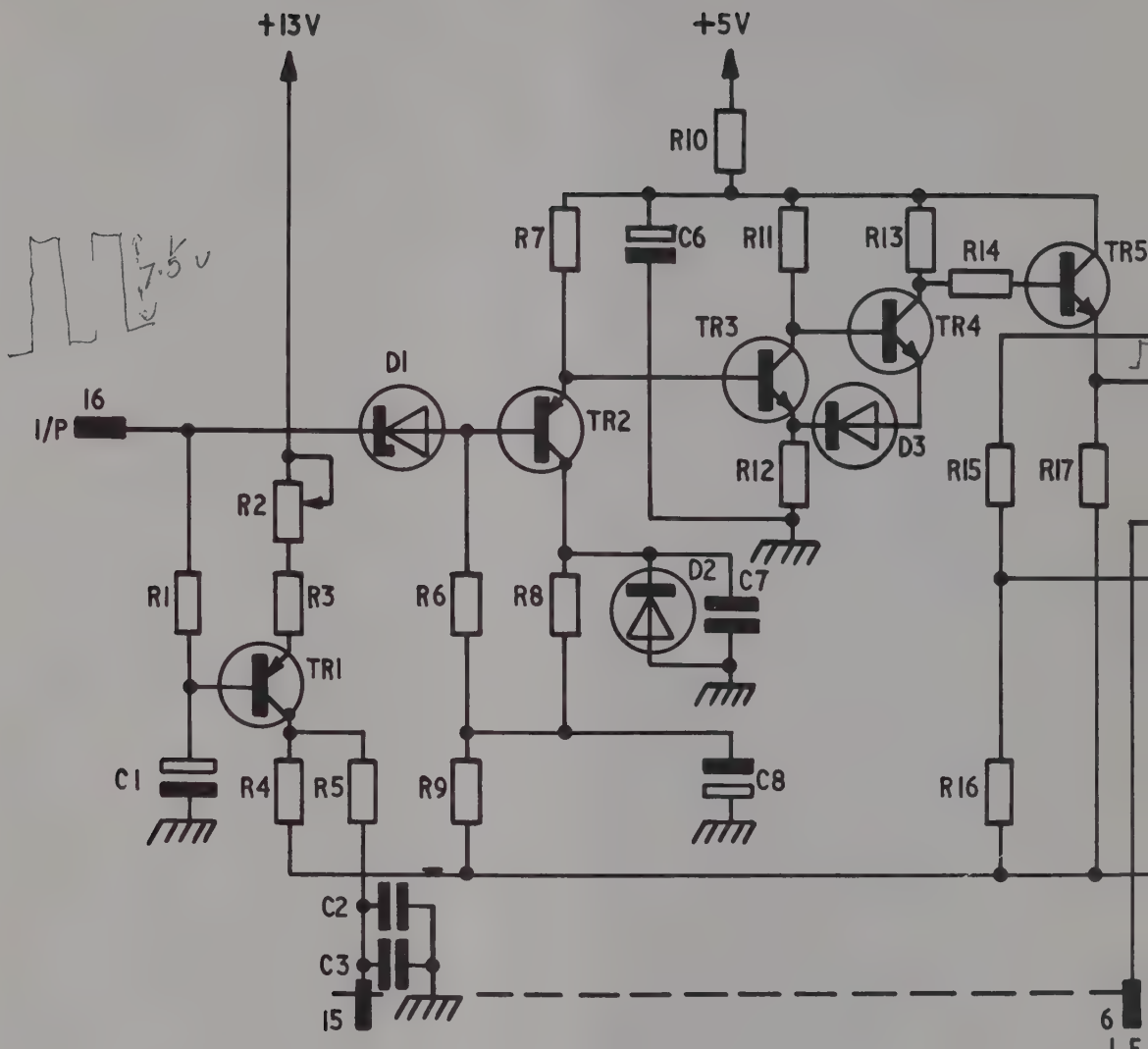
VIEWED FROM COMPONENT SIDE.

SCALE 3/4 FULL SIZE.

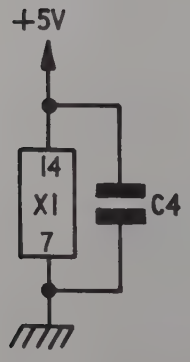
PULSE SHAPER

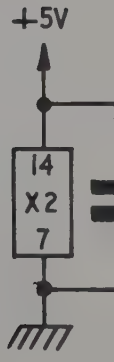
TYPE 77/310

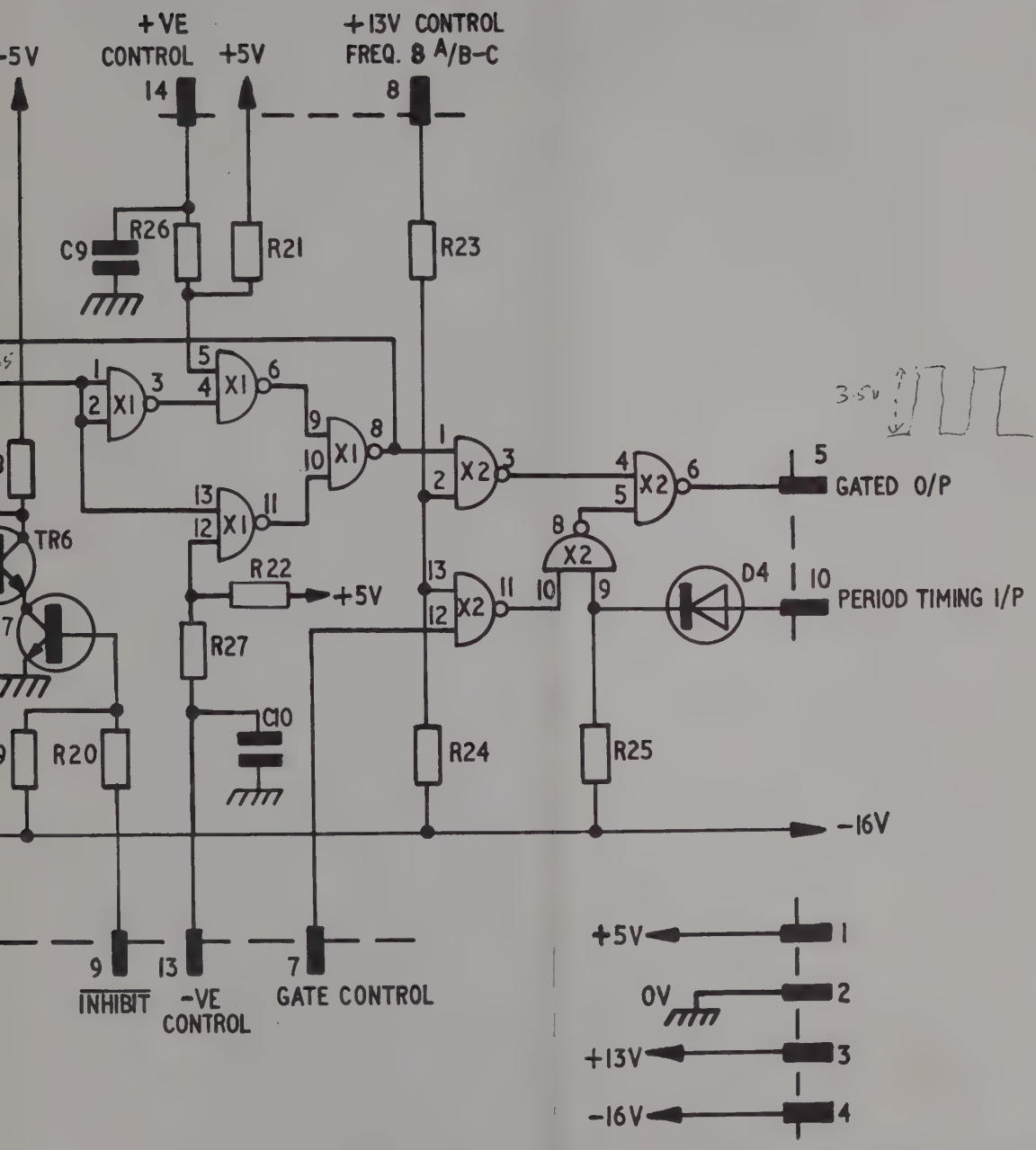
BL 77/310



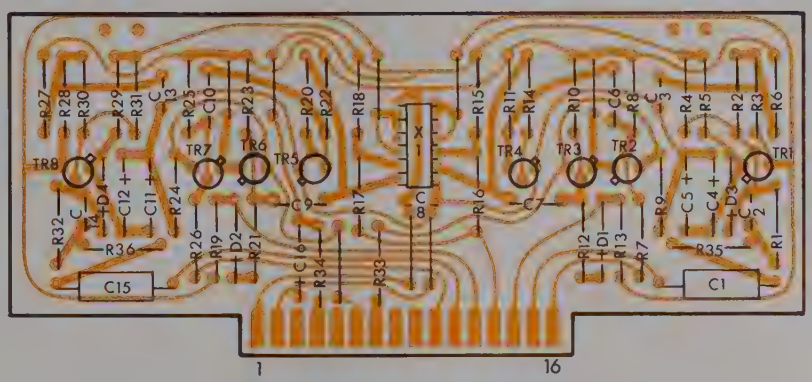
NOTE: CONNECTIONS THUS:- —|— REFER TO EDGE CONNECTOR.







PULSE SHAPER
CIRCUIT DIAGRAM
Type 77/310
E68/94

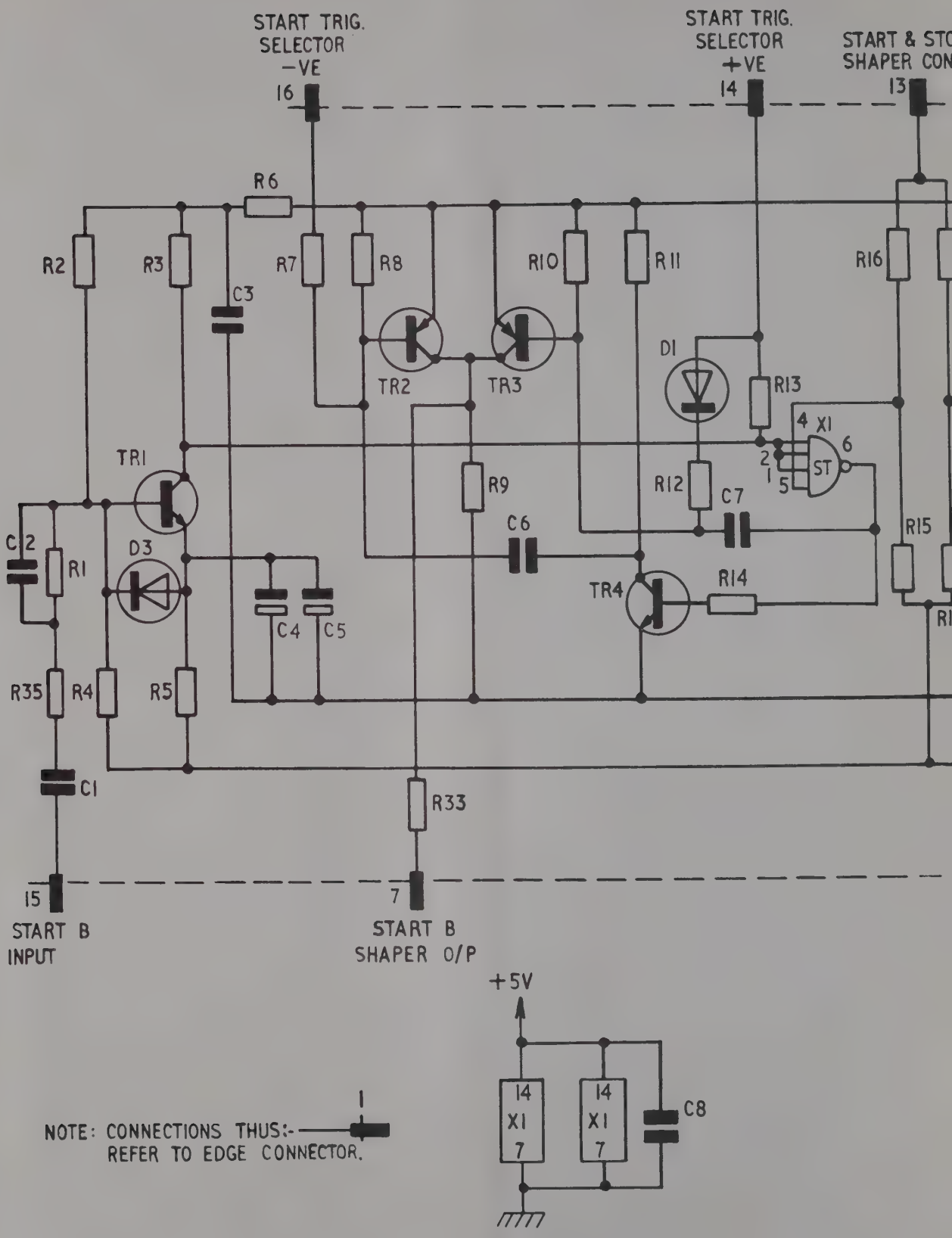


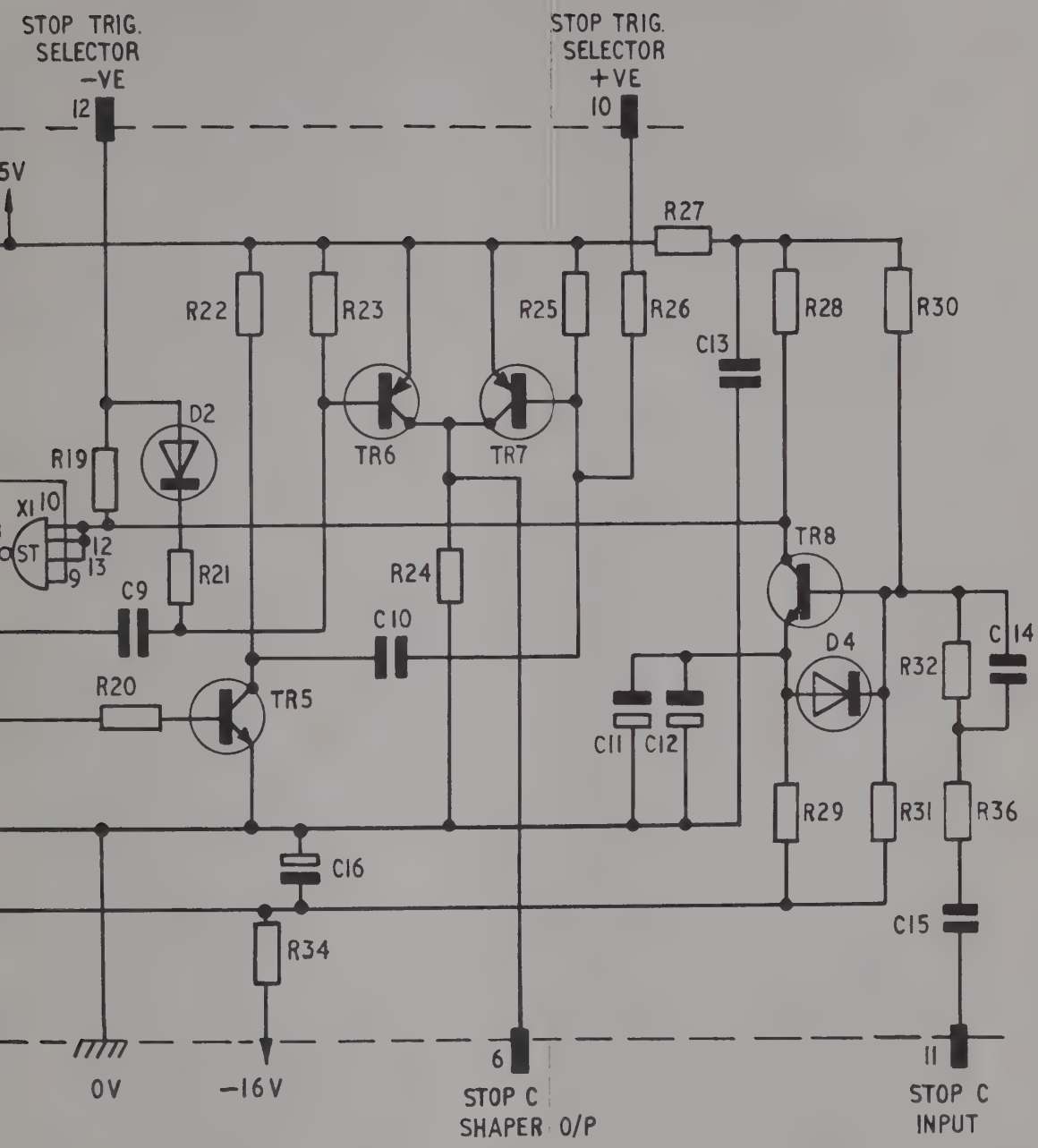
VIEWED FROM NON-COMPONENT SIDE.

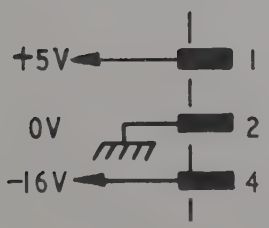
SCALE 3/4 FULL SIZE.

STOP & START SHAPERS
TYPE 77/320

BL
77/320


START TRIG. SELECTOR −VE
16
START TRIG. SELECTOR +VE
14
START & STO SHAPER CON
13
R6
R2
R3
C3
R7
R8
R10
R11
R16
TR2
TR3
D1
R13
4 X1
6
2
1
5
ST
TR1
R9
R12
C7
C6
R15
C2
R1
D3
C4
C5
TR4
R14
R35
R4
R5
C1
R33
15
START B INPUT
7
START B SHAPER O/P
+5V
14
X1
7
14
X1
7
C8
NOTE: CONNECTIONS THUS:- 1
REFER TO EDGE CONNECTOR.



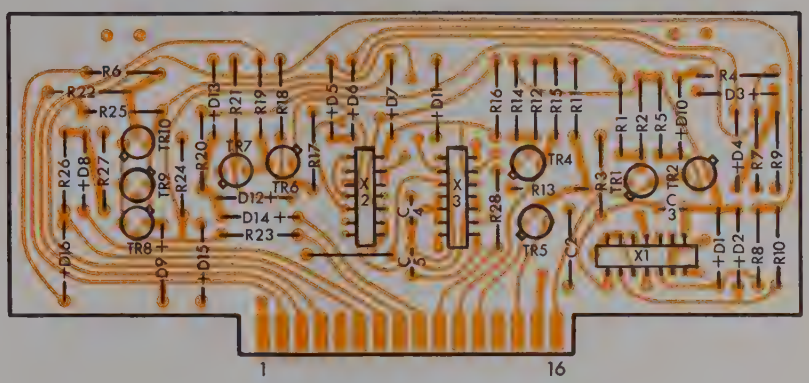


STOP & START SHAPERS

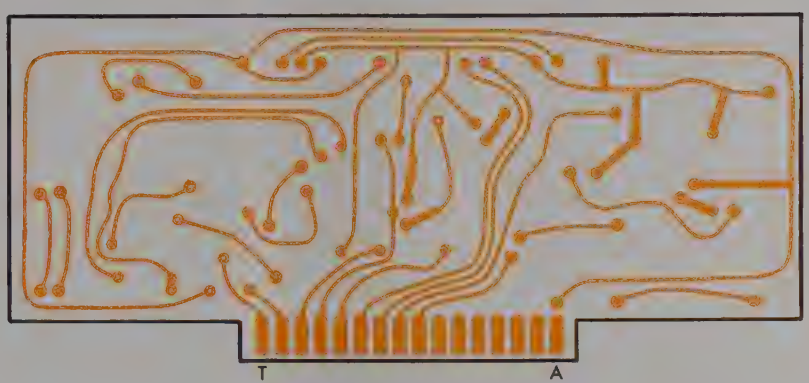
CIRCUIT DIAGRAM

Type 77/320

DRG. No. E69/01



VIEWED FROM NON-COMPONENT SIDE



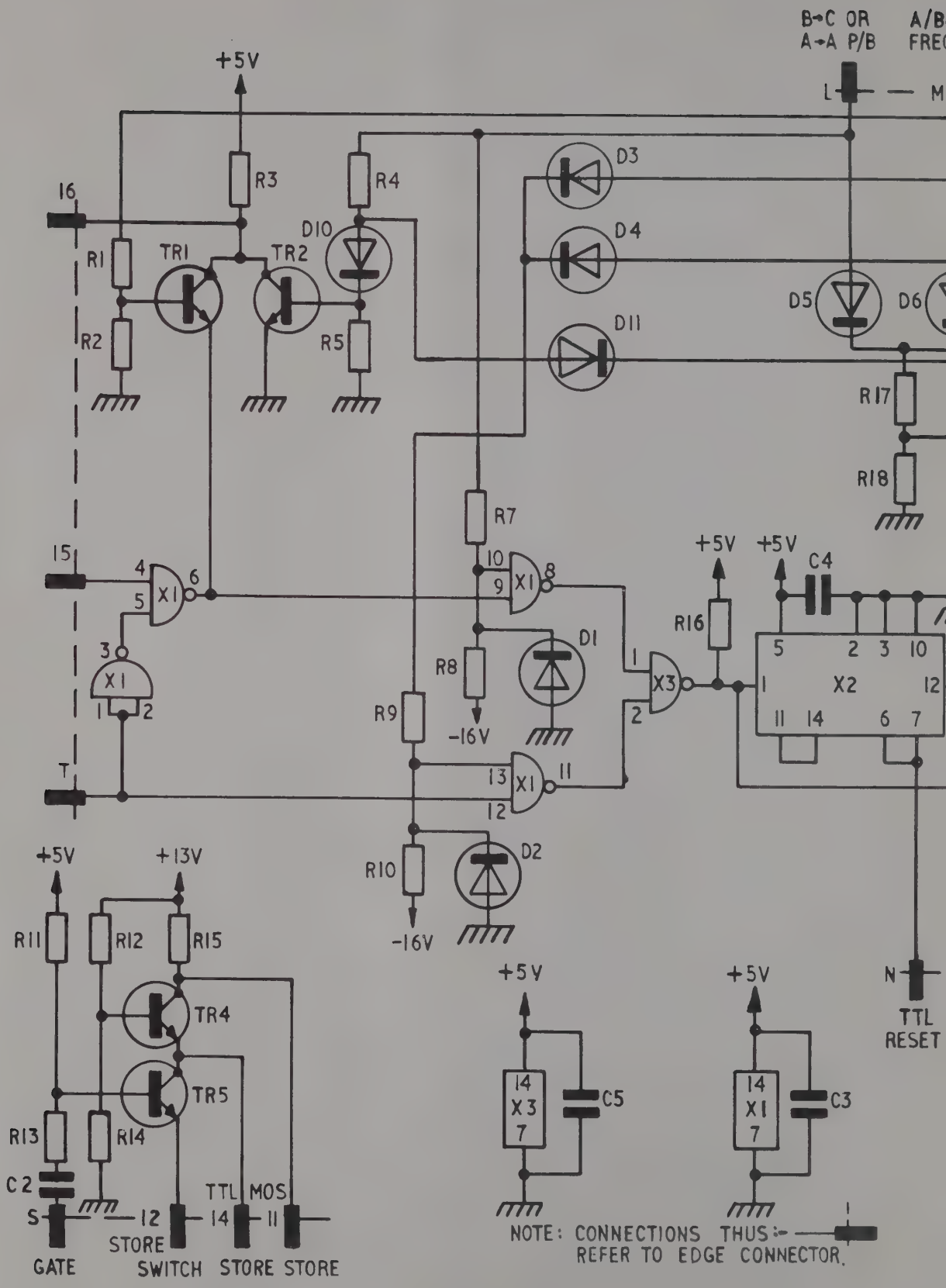
VIEWED FROM COMPONENT SIDE.

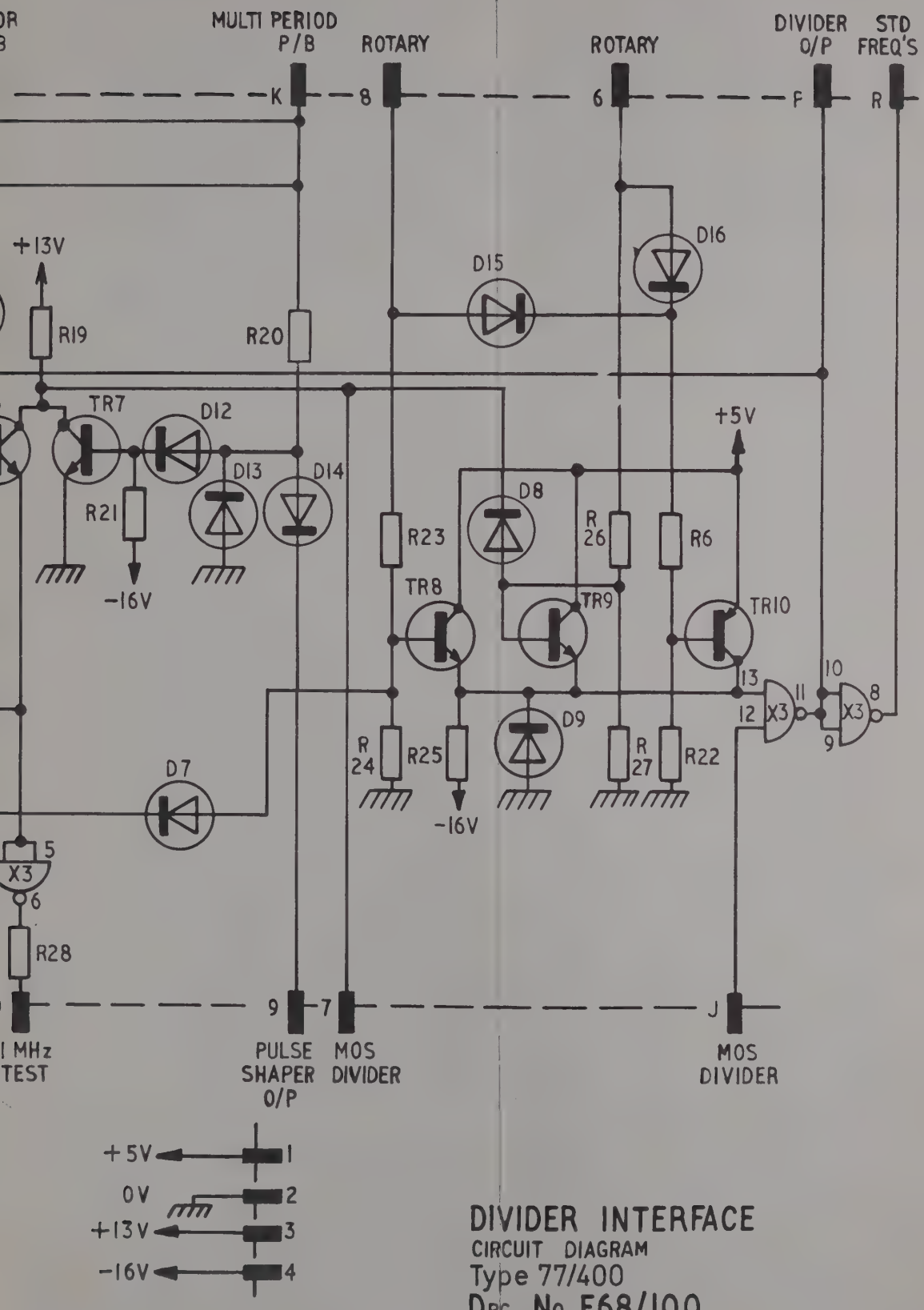
SCALE 3/4 FULL SIZE.

DIVIDER INTERFACE

TYPE 77/400

BL 77/400


B→C OR A→A P/B
A/B FREQ
L
M
+5V
R3
R4
16
R1
TR1
TR2
D10
R2
R5
D3
D4
D5
D6
D11
R17
R18
R7
15
4
5
X1
6
10
9
X1
8
+5V
+5V
C4
R16
3
X1
1
2
R8
D1
R9
-16V
1
X3
2
5
2
3
10
1
X2
12
11
14
6
7
T
13
X1
11
12
R10
D2
-16V
+5V
+13V
R11
R12
R15
TR4
TR5
R13
R14
C2
S
12
STORE
SWITCH
TTL
14
MOS
11
GATE
STORE
STORE
+5V
14
X3
7
C5
+5V
14
X1
7
C3
N
TTL
RESET
NOTE: CONNECTIONS THUS :- REFER TO EDGE CONNECTOR.

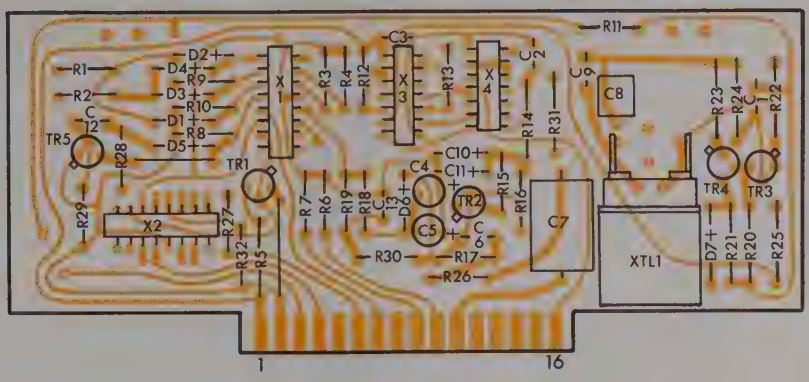


DIVIDER INTERFACE

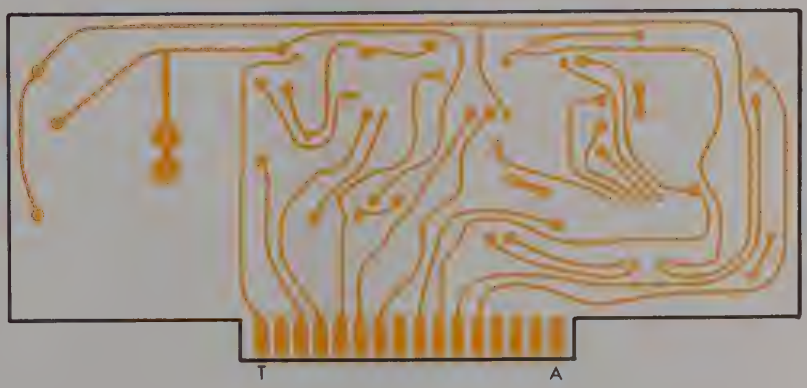
CIRCUIT DIAGRAM

Type 77/400

Drg. No. E68/100



VIEWED FROM NON-COMPONENT SIDE.



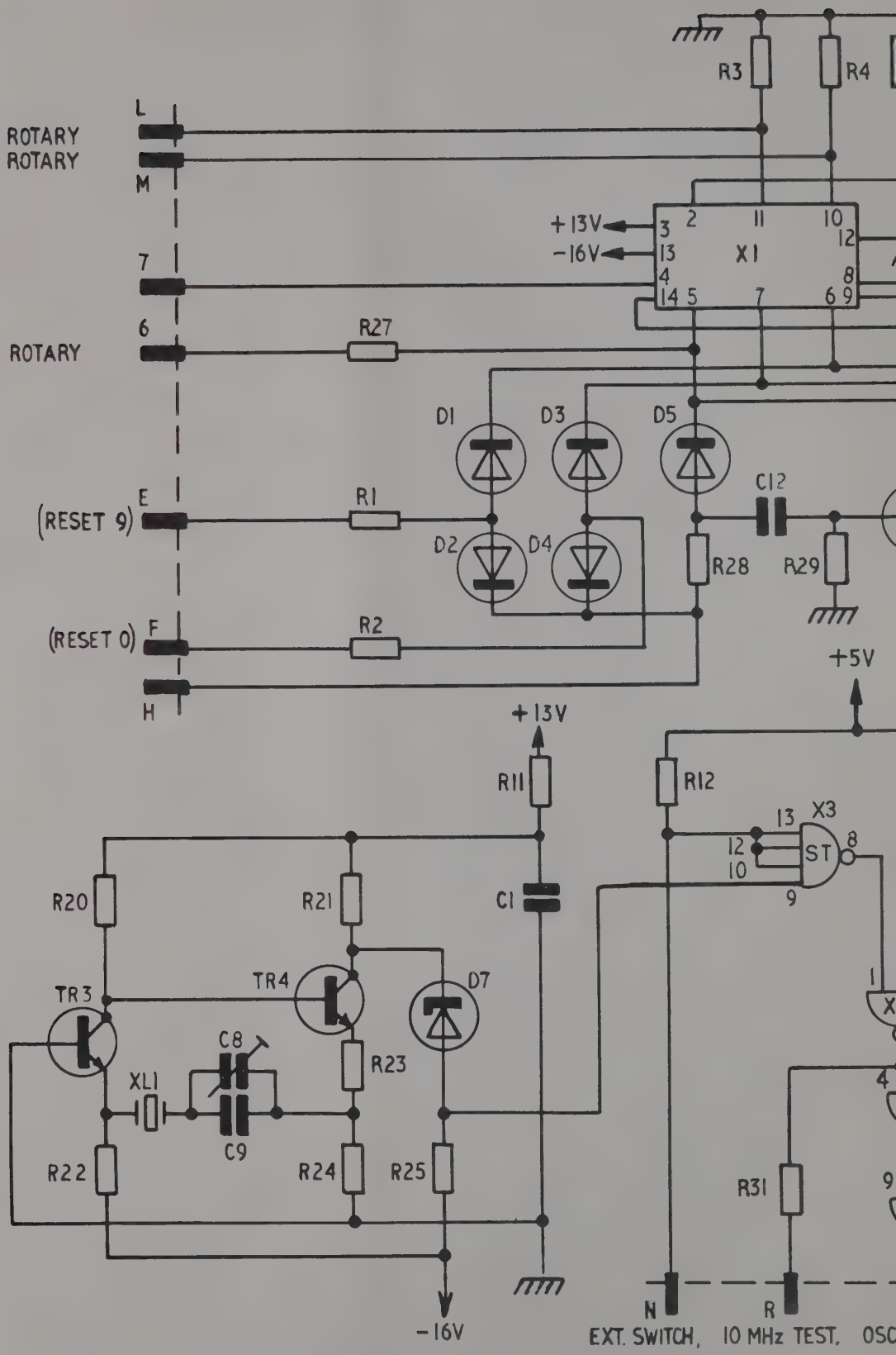
VIEWED FROM COMPONENT SIDE.

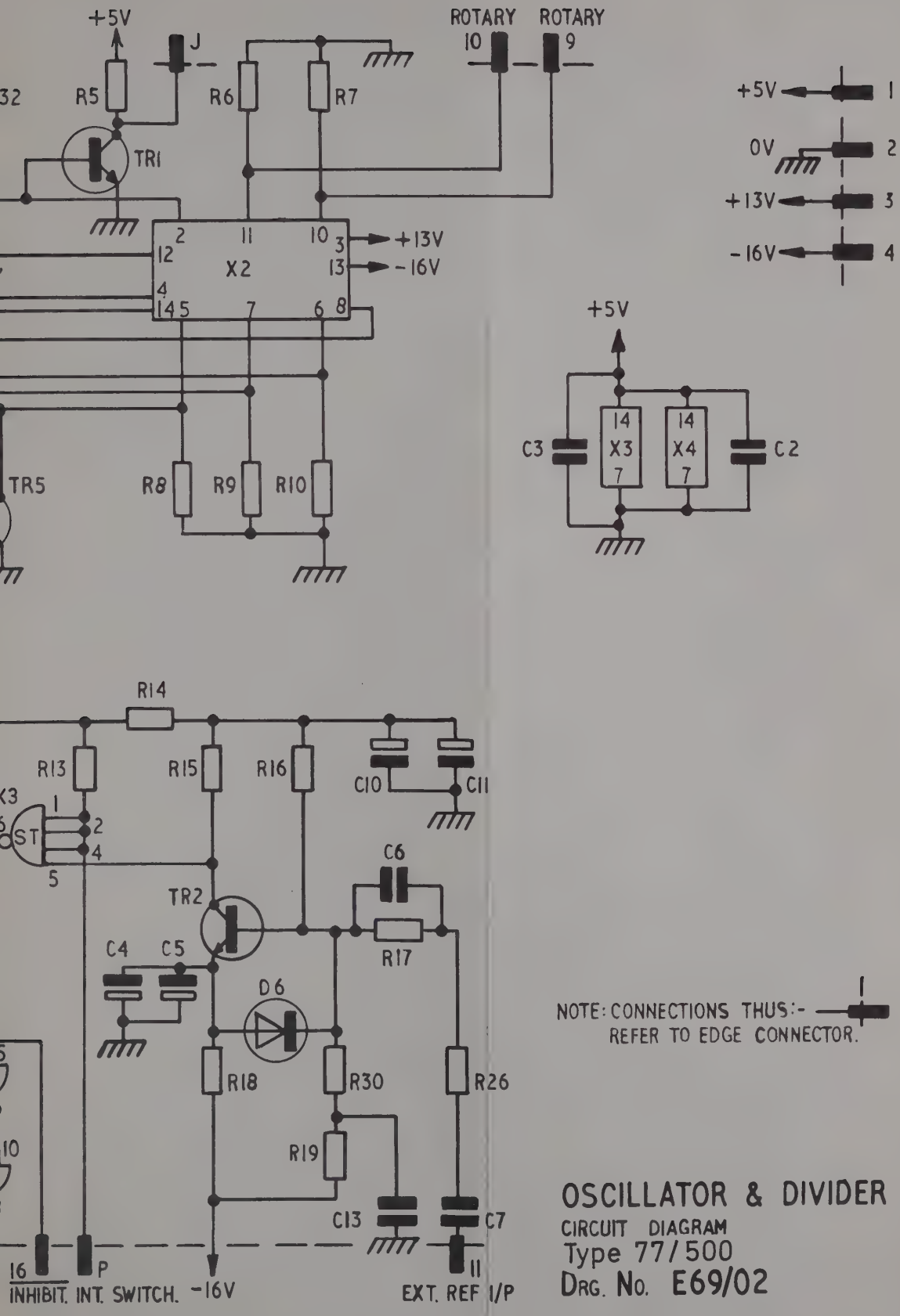
SCALE 3/4 FULL SIZE.

OSCILLATOR & DIVIDER

TYPE 77/500

BL 77/500

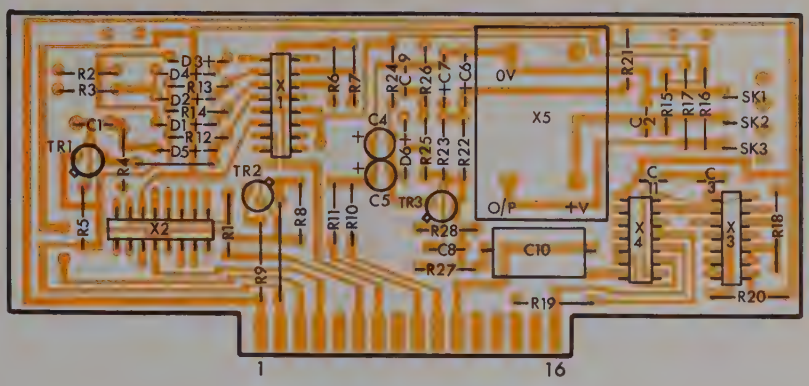

R3
R4
L
ROTARY
ROTARY
M
+13V
-16V
X1
7
6
ROTARY
R27
D1
D3
D5
C12
E
(RESET 9)
R1
D2
D4
R28
R29
(RESET 0)
F
R2
H
+5V
+13V
R11
R12
X3
ST
R20
R21
C1
TR3
TR4
D7
C8
XL1
C9
R23
R22
R24
R25
R31
-16V
N
R
EXT. SWITCH,
10 MHz TEST,



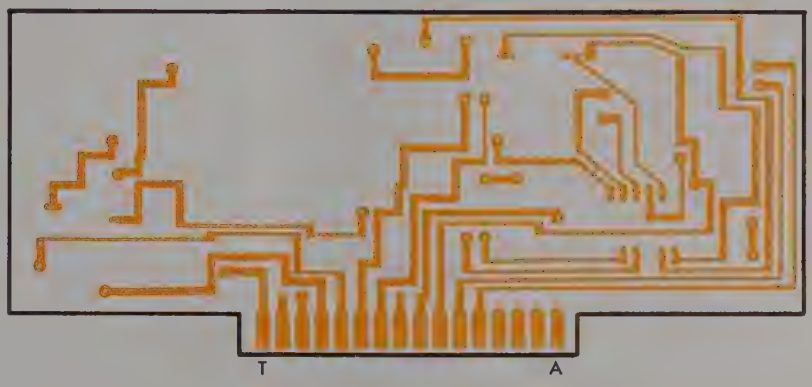
NOTE: CONNECTIONS THUS:- 1
REFER TO EDGE CONNECTOR.

OSCILLATOR & DIVIDER

CIRCUIT DIAGRAM
Type 77/500
DRG. No. E69/02



VIEWED FROM NON-COMPONENT SIDE.



VIEWED FROM COMPONENT SIDE.

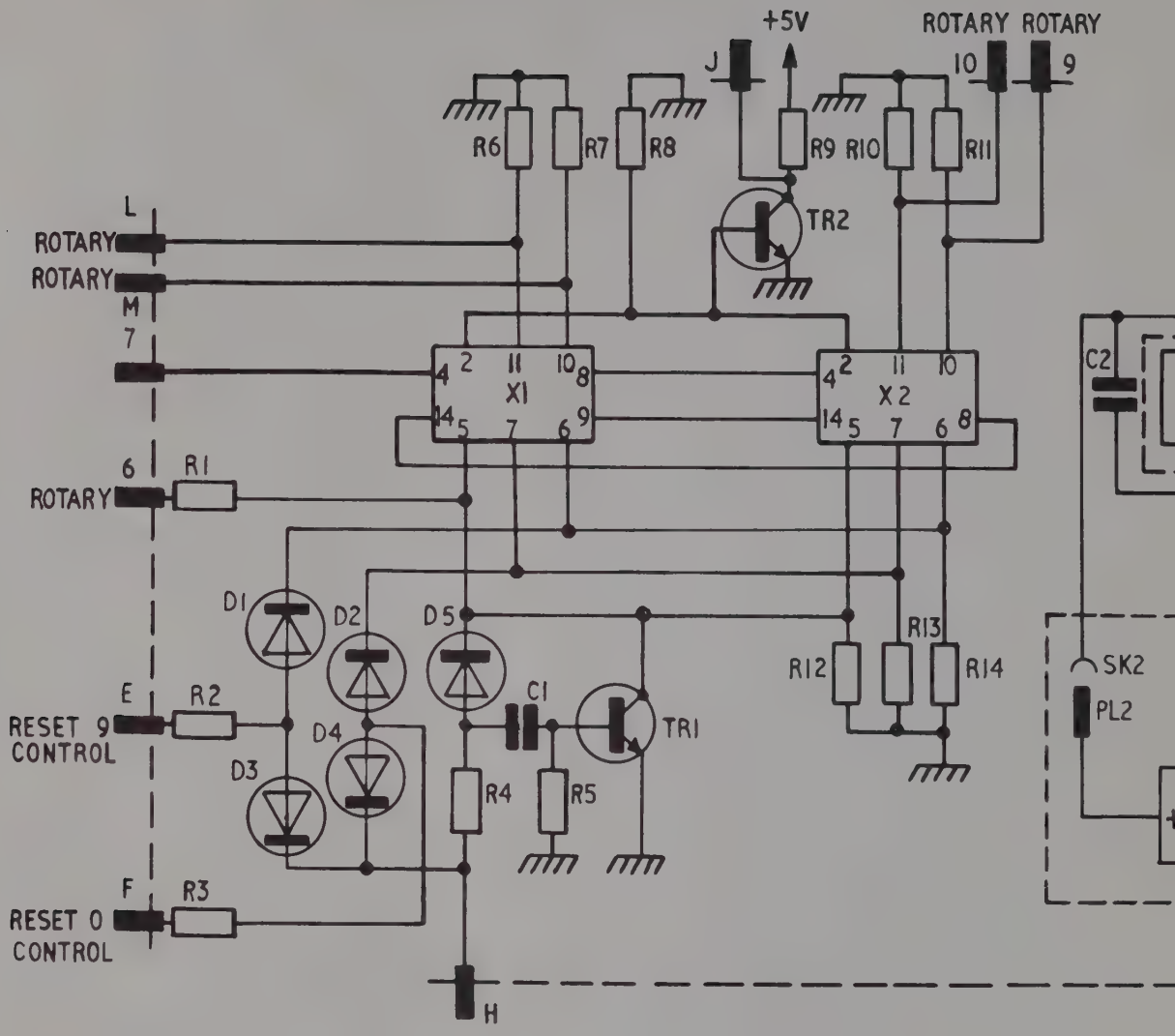
SCALE 3/4 FULL SIZE.

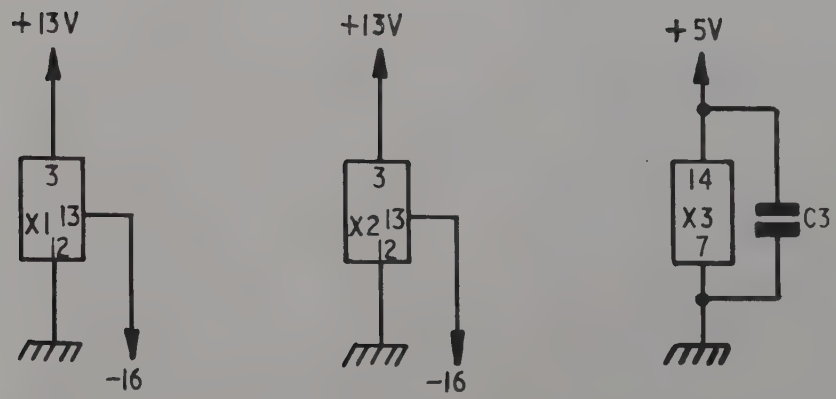
NOTE. FOR TYPE 77/510 X5 IS MOUNTED REMOTELY.

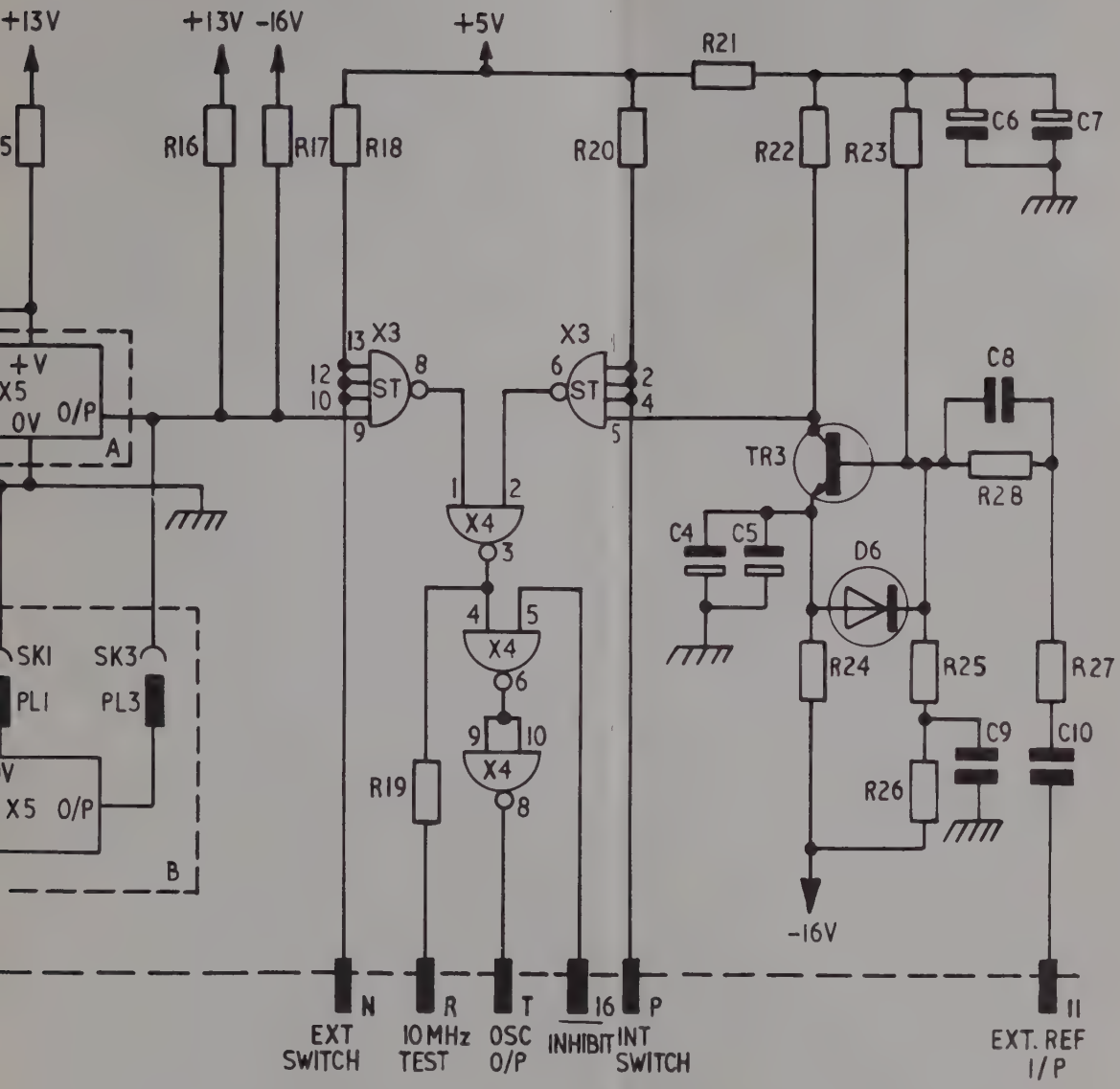
OSCILLATOR & DIVIDER

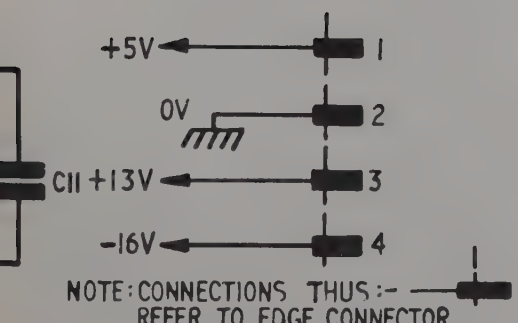
TYPES 77/510 & 77/511

BL 77/510 & 77/511


+5V
ROTARY
ROTARY
J
10
9
R6
R7
R8
R9
R10
R11
TR2
L
ROTARY
ROTARY
M
7
X1
X2
C2
6
ROTARY
R1
D1
D2
D5
R13
R12
R14
SK2
PL2
E
RESET 9
CONTROL
R2
D4
C1
TR1
D3
R4
R5
F
RESET 0
CONTROL
R3
H


+13V
3
X1
13
12
-16
+13V
3
X2
13
12
-16
+5V
14
X3
7
C3
+5V
14
X4
7





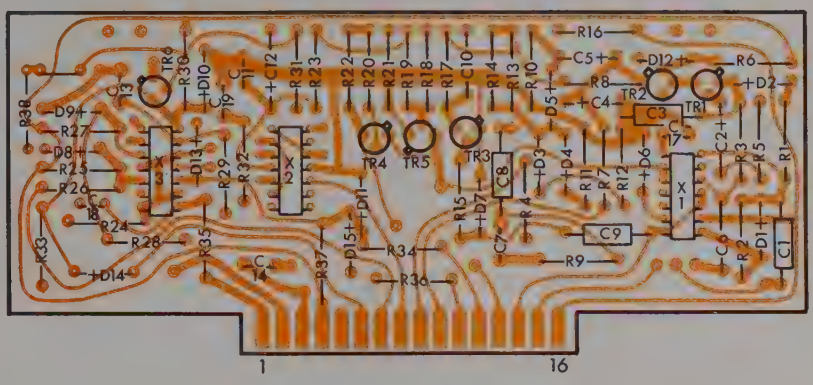
FOR 77/510 DELETE A *(TF 2416/2)*
FOR 77/511 DELETE B *(TF 2416/1)*

OSCILLATOR & DIVIDER

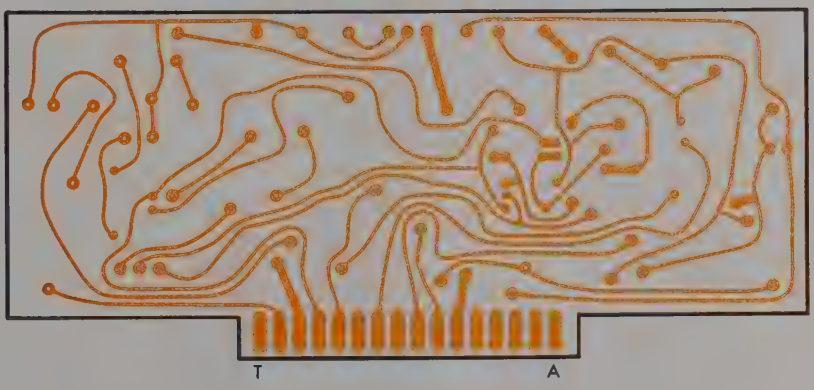
CIRCUIT DIAGRAM

Type 77/510 & 77/511

DRG. No. E69/22



VIEWED FROM NON-COMPONENT SIDE.



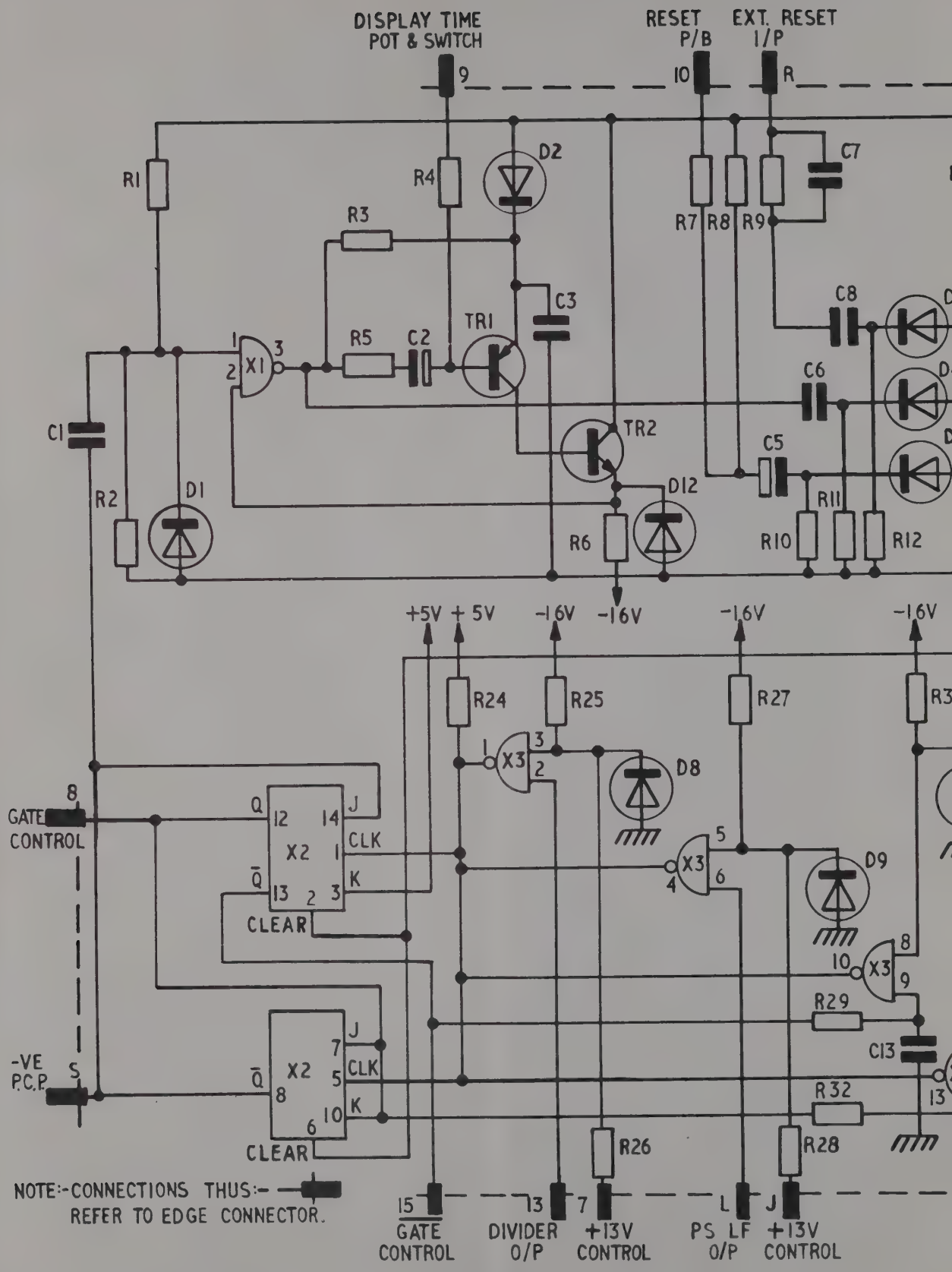
VIEWED FROM COMPONENT SIDE.

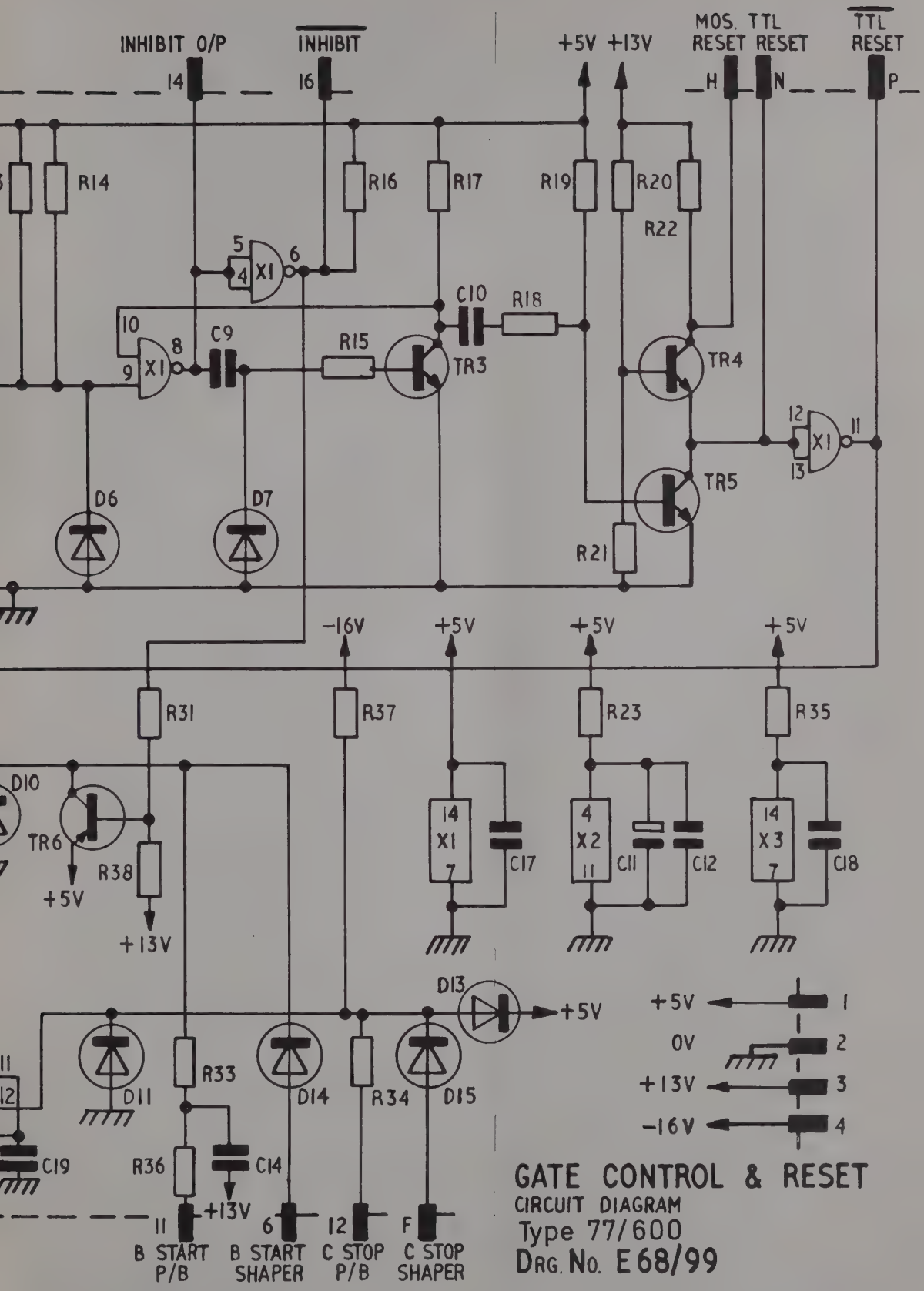
SCALE 3/4 FULL SIZE.

GATE CONTROL & RESET

TYPE 77/600

BL 77/600


DISPLAY TIME POT & SWITCH
RESET P/B
EXT. RESET I/P
9
10
R
R1
R4
D2
R3
C7
R7
R8
R9
C8
C3
TR1
R5
C2
X1
C6
C1
TR2
C5
R2
D1
D12
R11
R6
R10
R12
+5V
+5V
-16V
-16V
-16V
-16V
R24
R25
R27
X3
D8
GATE CONTROL
8
Q
12
14
J
CLK
X2
1
Q̄
13
2
3
K
CLEAR
D9
10
R29
C13
-VE P.C.P.
S
7
8
6
10
R32
R26
R28
NOTE:-CONNECTIONS THUS:-
REFER TO EDGE CONNECTOR.
15
13
7
L
J
GATE CONTROL
DIVIDER O/P
+13V CONTROL
PS LF O/P
+13V CONTROL

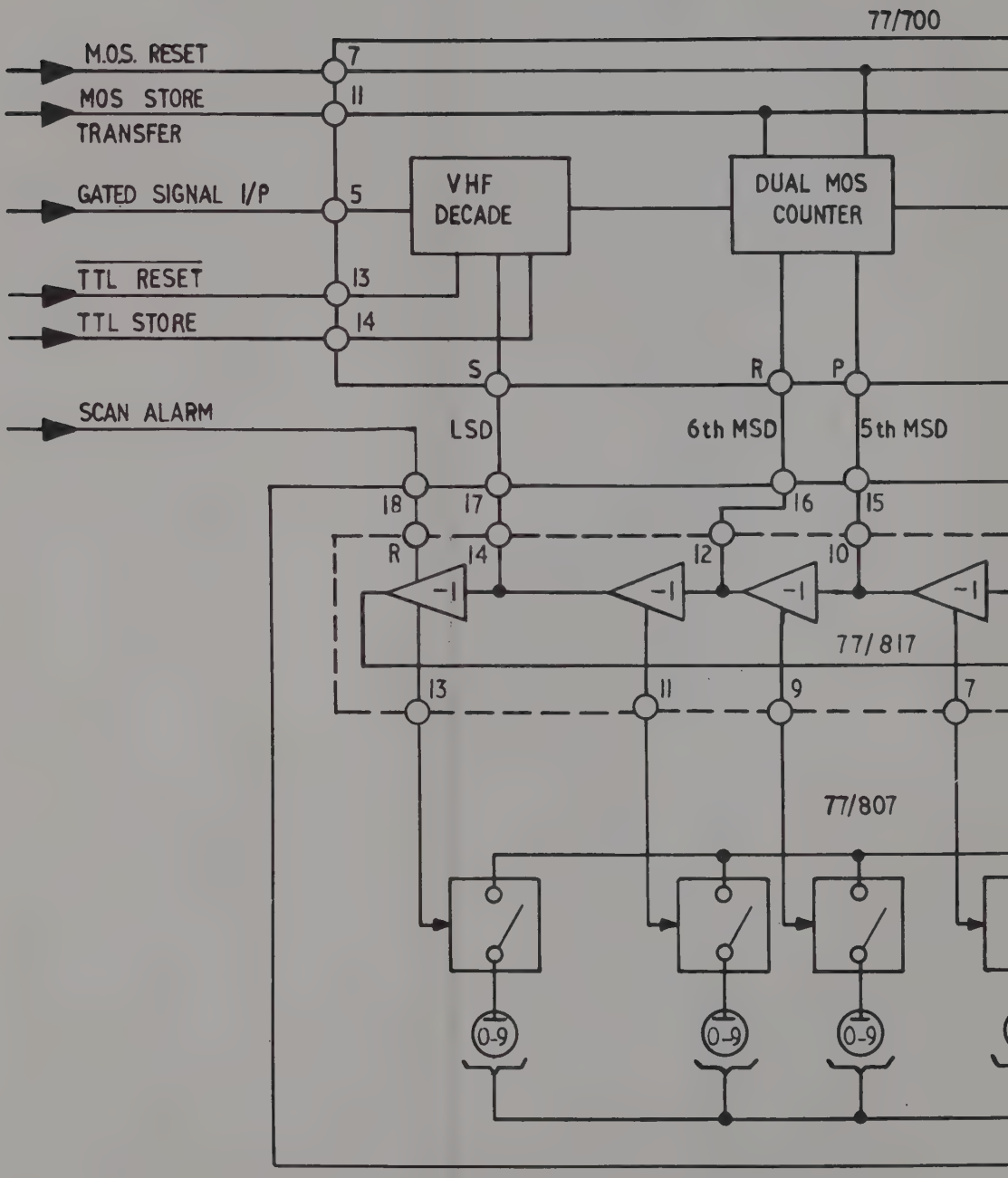


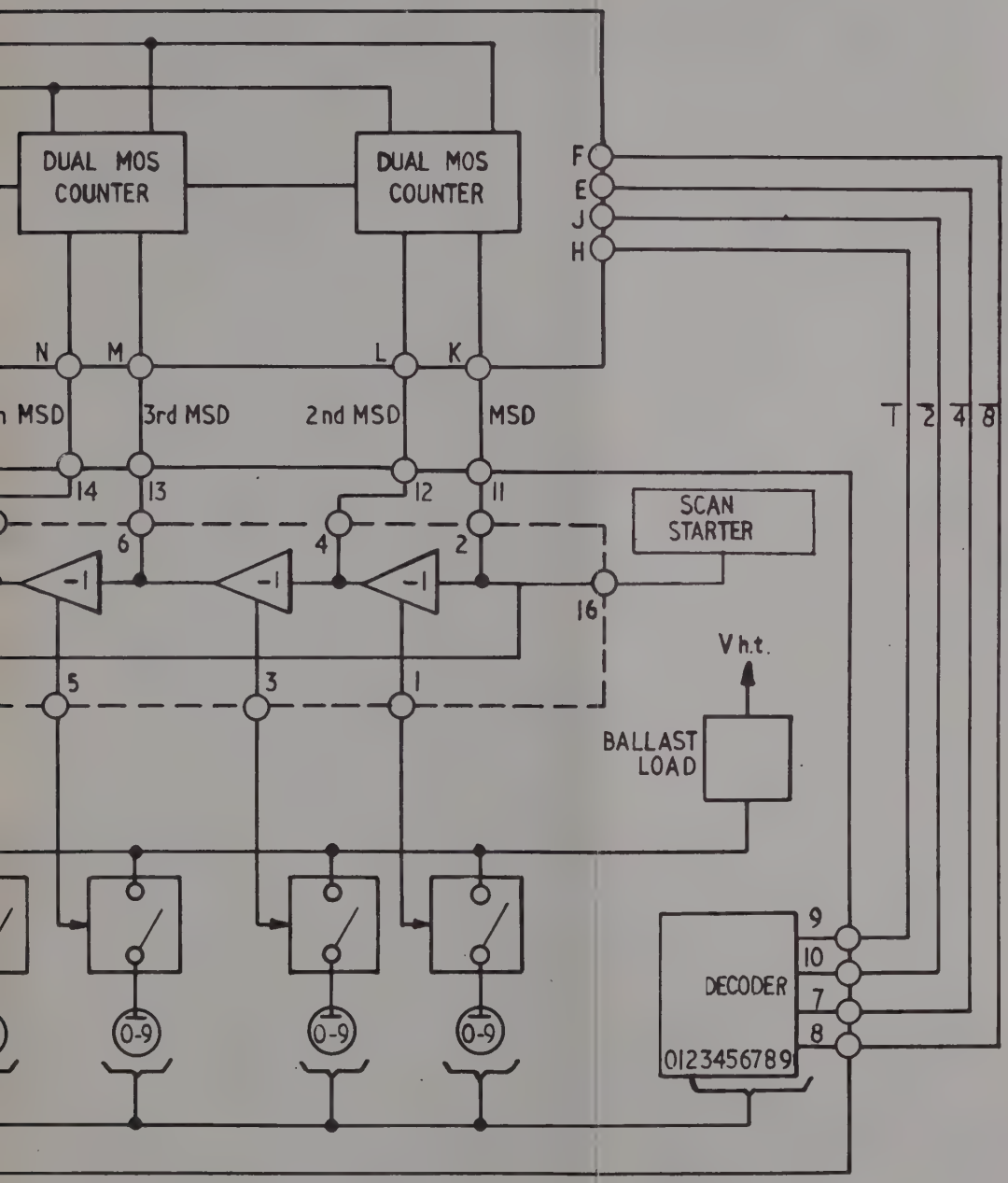
GATE CONTROL & RESET

CIRCUIT DIAGRAM

Type 77/600

DRG. NO. E68/99


77/700
M.O.S. RESET
MOS STORE
TRANSFER
GATED SIGNAL I/P
TTL RESET
TTL STORE
SCAN ALARM
7
11
5
13
14
VHF
DECADE
DUAL MOS
COUNTER
S
R
P
LSD
6th MSD
5th MSD
18
17
16
15
R
14
12
10
-1
77/817
13
11
9
7
77/807
0-9

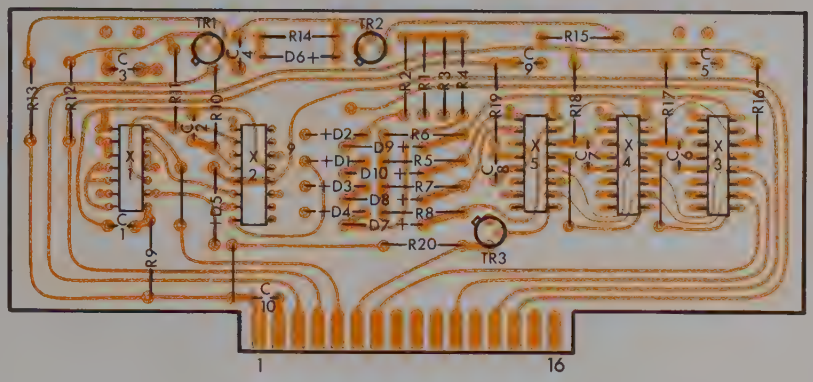


COUNTER & SCANNING DISPLAY

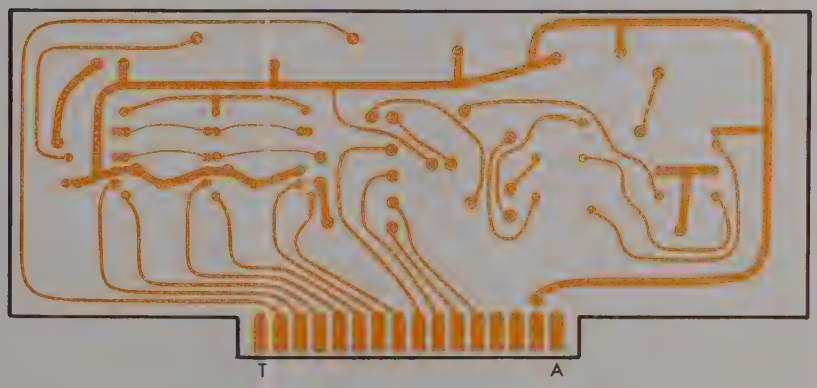
SCHEMATIC DIAGRAM

Type 77/700, 77/807 & 77/817

DRG. NO. E69/24



VIEWED FROM NON-COMPONENT SIDE.



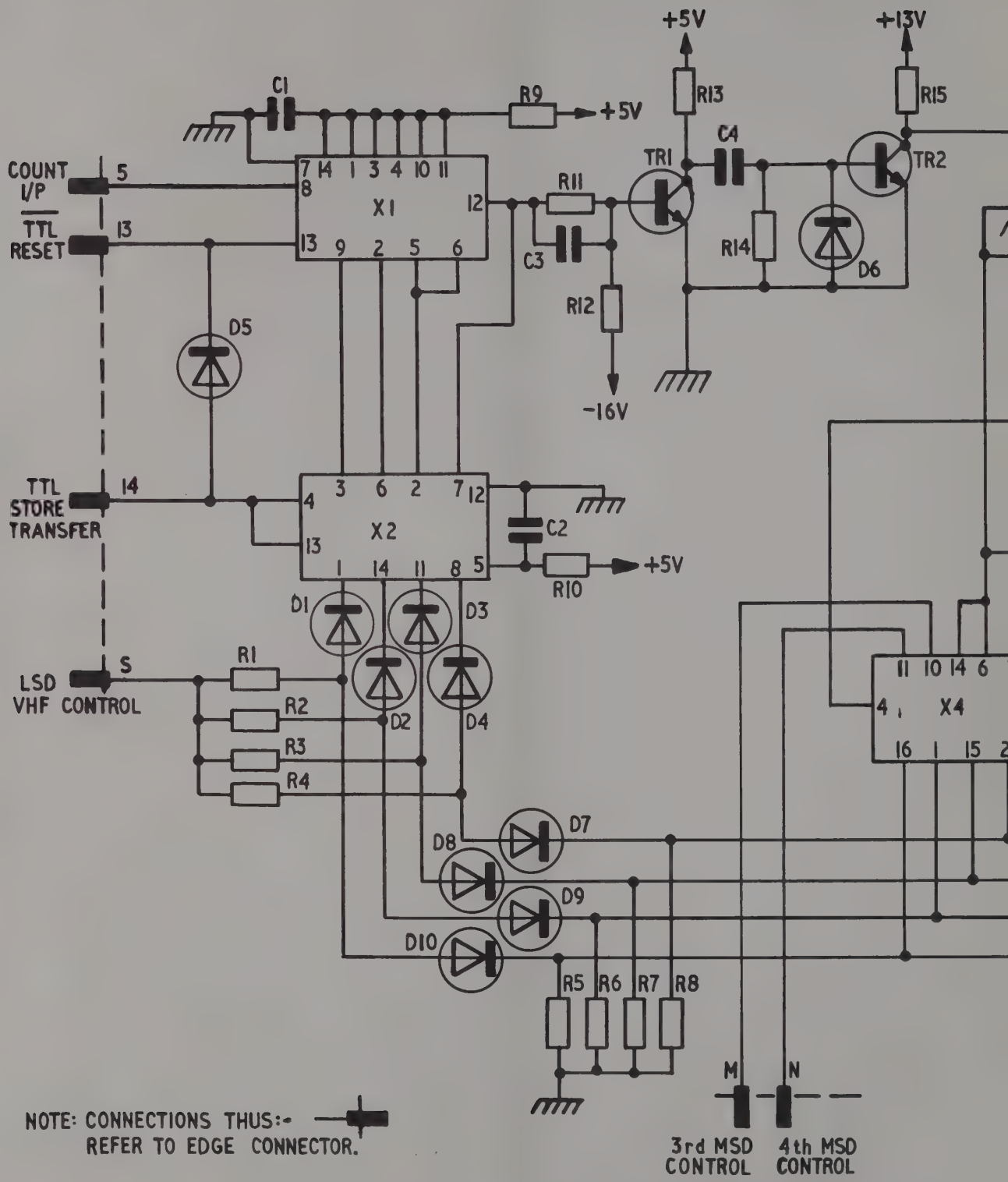
VIEWED FROM COMPONENT SIDE.

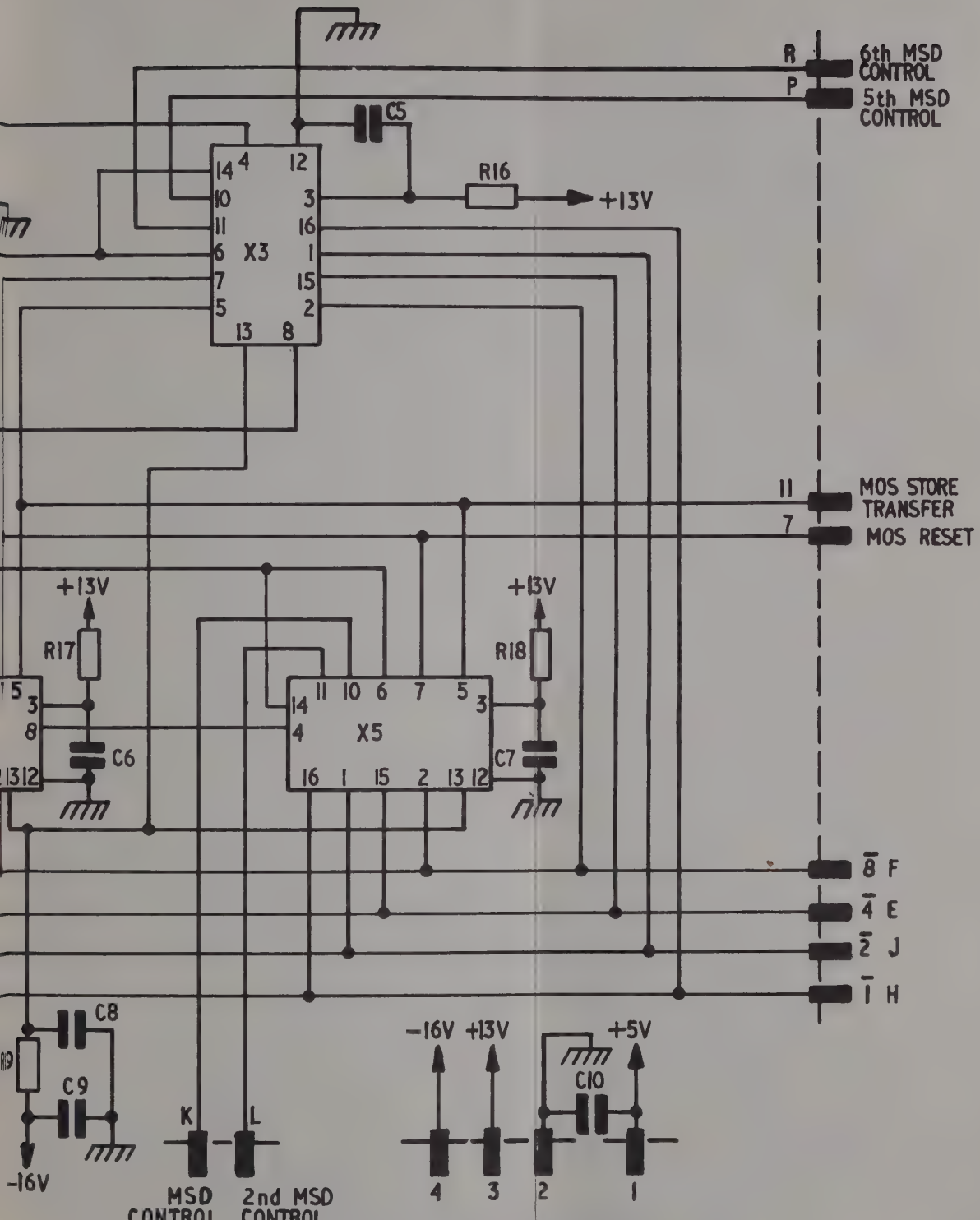
SCALE 3/4 FULL SIZE.

COUNTER

TYPE 77/700

BL 77/700


+5V
+13V
C1
R9
+5V
R13
R15
C4
TR1
TR2
COUNT I/P
5
TTL RESET
13
X1
R11
C3
R14
D6
R12
-16V
D5
TTL STORE TRANSFER
14
X2
C2
+5V
R10
D1
D3
LSD VHF CONTROL
S
R1
R2
R3
R4
D2
D4
X4
D7
D8
D9
D10
R5
R6
R7
R8
M
N
3rd MSD CONTROL
4th MSD CONTROL
NOTE: CONNECTIONS THUS:-
REFER TO EDGE CONNECTOR.

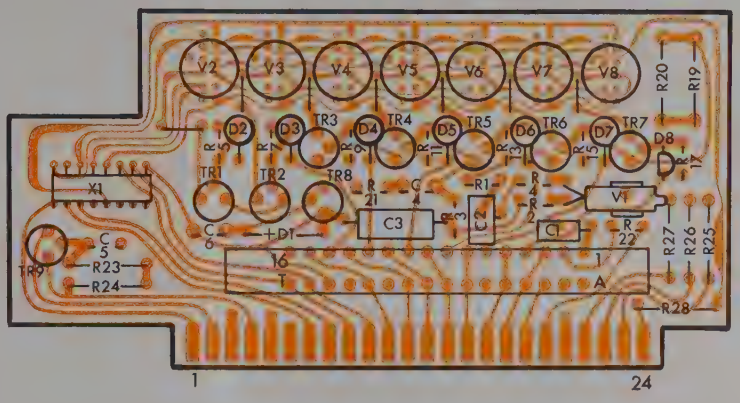


COUNTER

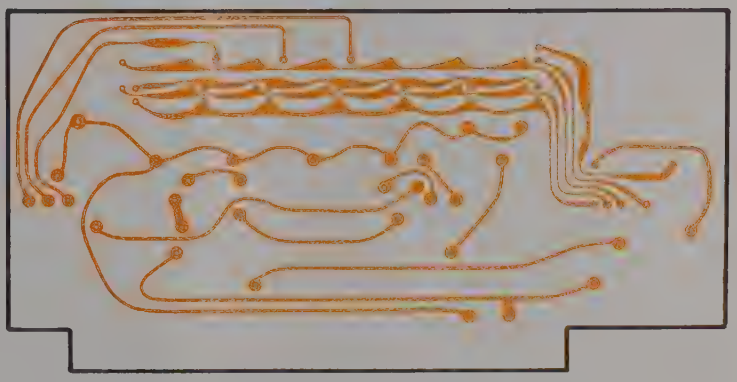
CIRCUIT DIAGRAM

Type 77/700

DRG. No. E68/98



VIEWED FROM NON-COMPONENT SIDE.



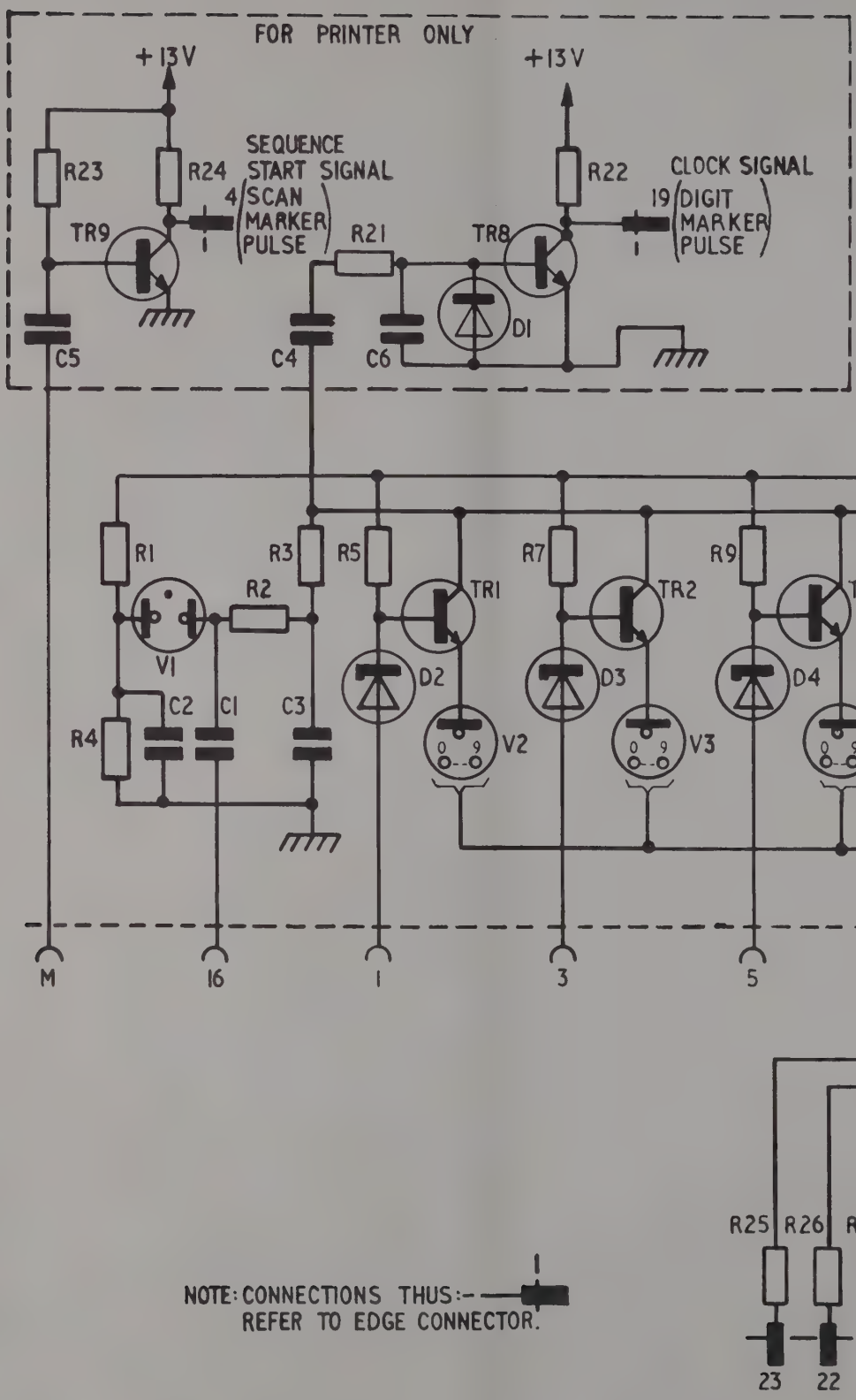
VIEWED FROM COMPONENT SIDE.

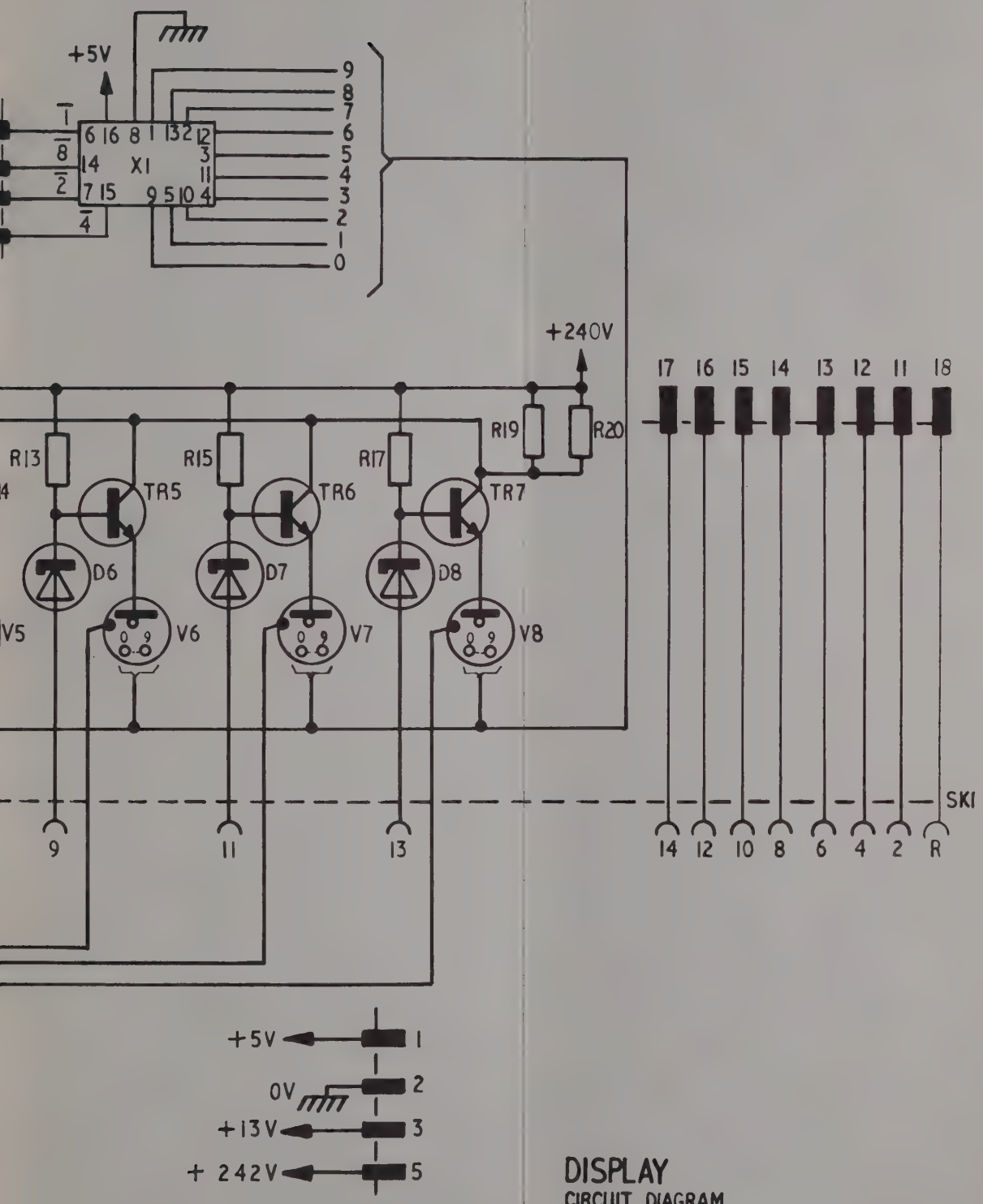
SCALE 3/4 FULL SIZE.

DISPLAY

TYPE 77/807

BL 77/807


FOR PRINTER ONLY
+13V
+13V
R23
R24
SEQUENCE START SIGNAL
4 SCAN MARKER PULSE
TR9
R21
TR8
R22
CLOCK SIGNAL
19 DIGIT MARKER PULSE
D1
C5
C4
C6
R1
R3
R5
R7
R9
R11
R2
TR1
TR2
TR3
V1
D2
D3
D4
D5
C2
C1
C3
R4
V2
V3
V4
M
16
1
3
5
7
R25
R26
R27
R28
23
22
21
24
NOTE: CONNECTIONS THUS:-
REFER TO EDGE CONNECTOR.

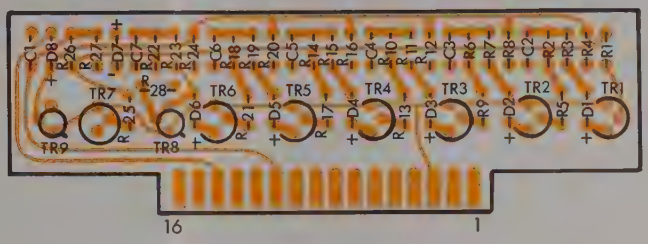


DISPLAY

CIRCUIT DIAGRAM

Type 77/807

Drg. No. E68/96



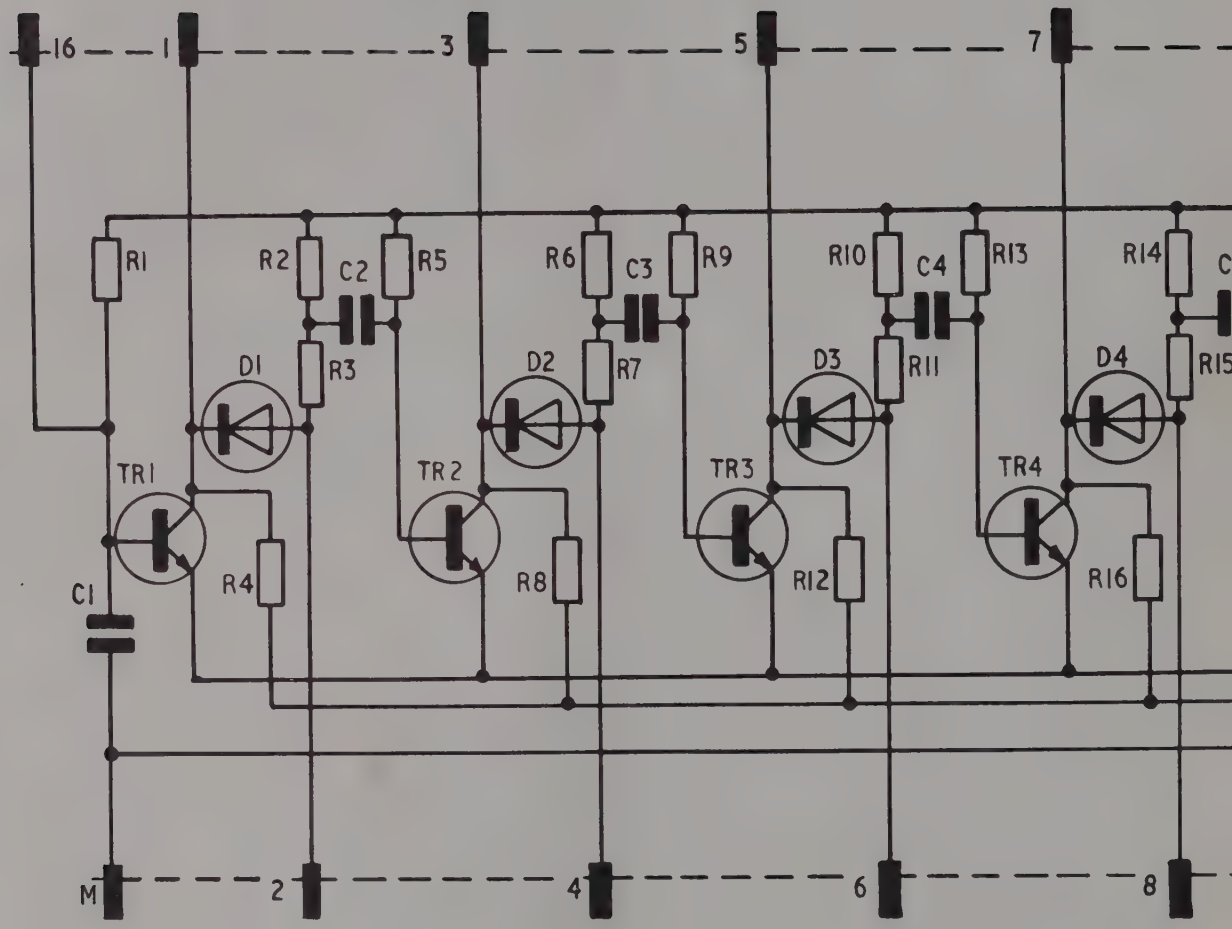
VIEWED FROM NON-COMPONENT SIDE.

VIEWED FROM COMPONENT SIDE.

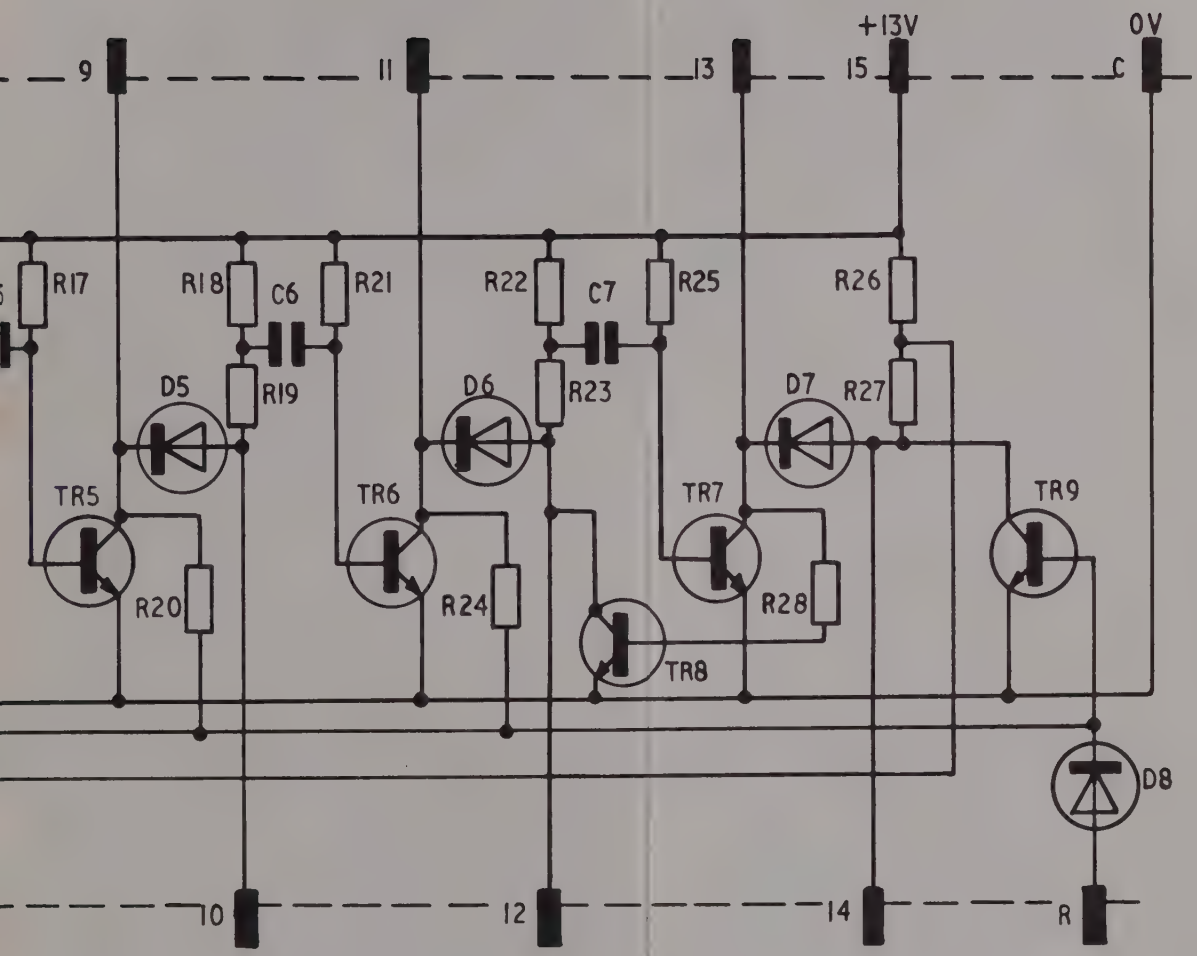
SCALE 3/4 FULL SIZE.

DISPLAY CONTROL
TYPE 77/817

BL 77/817



NOTE : CONNEC
REFER T



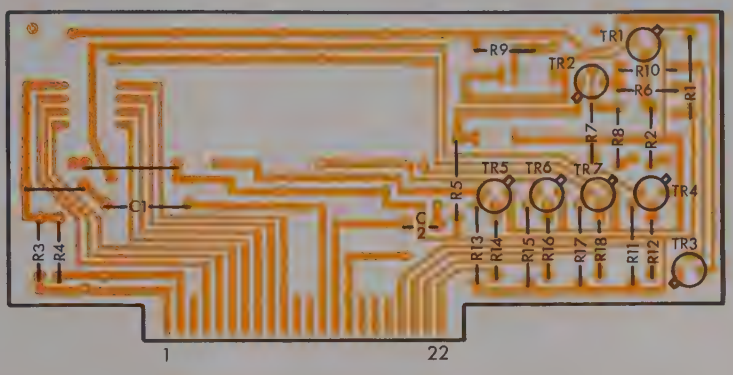
...IONS THUS :- —|—
...) EDGE CONNECTOR

DISPLAY CONTROL

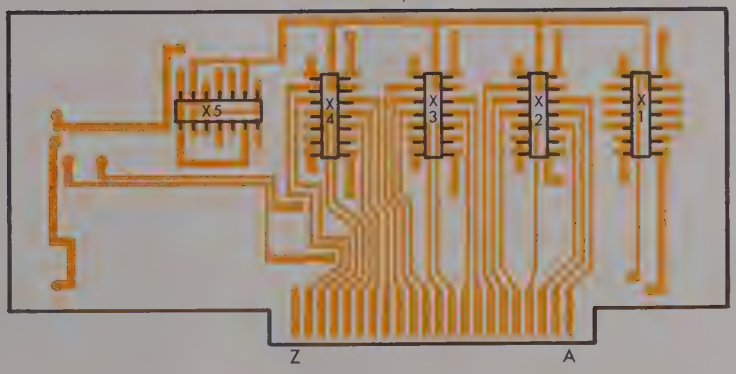
CIRCUIT DIAGRAM

Type 77/817

DRG. NO. E68/97



VIEWED FROM NON-COMPONENT SIDE.



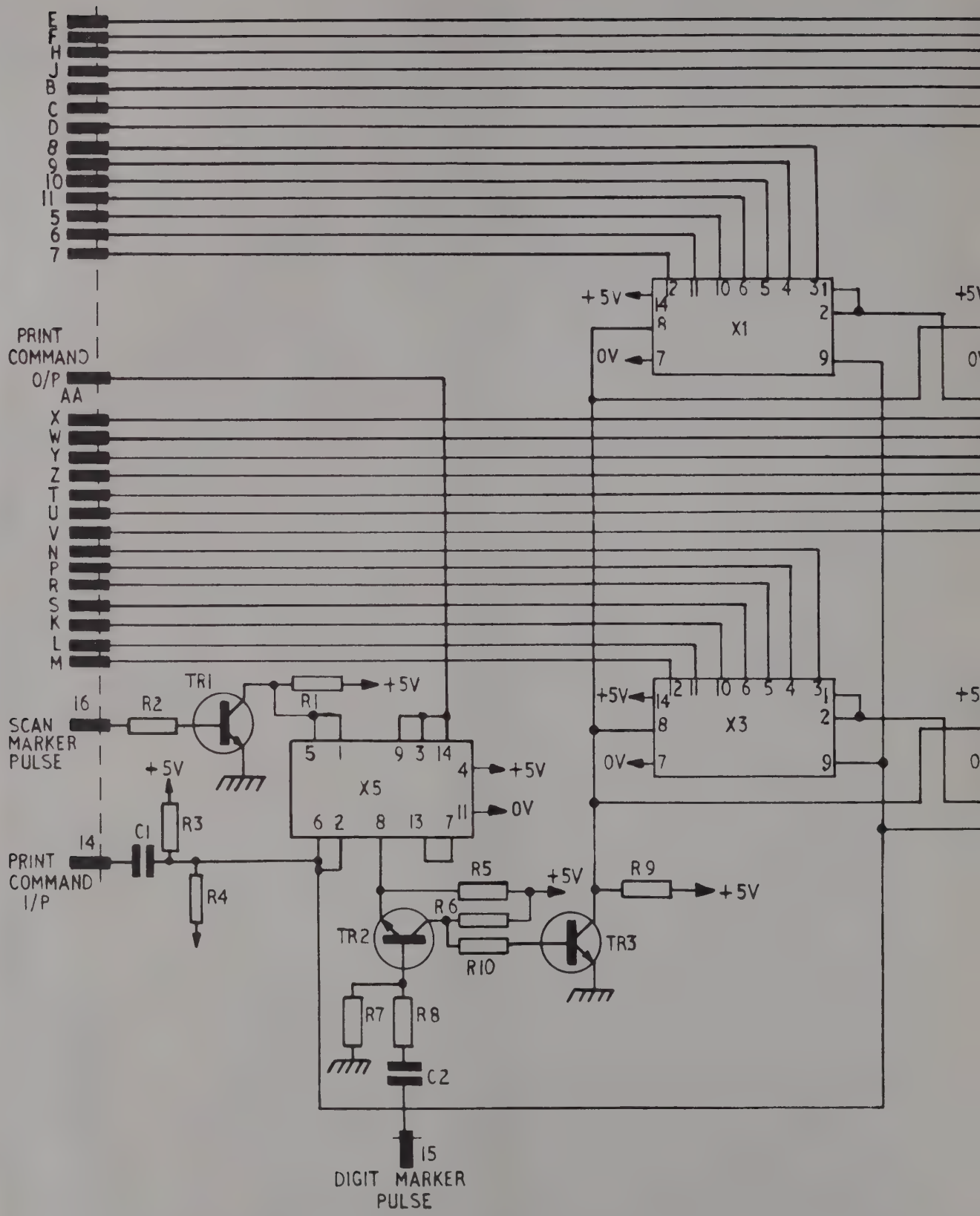
VIEWED FROM COMPONENT SIDE.

SCALE 3/4 FULL SIZE.

PARALLEL B.C.D. INTERFACE

TYPE 77/900

BL 77/900



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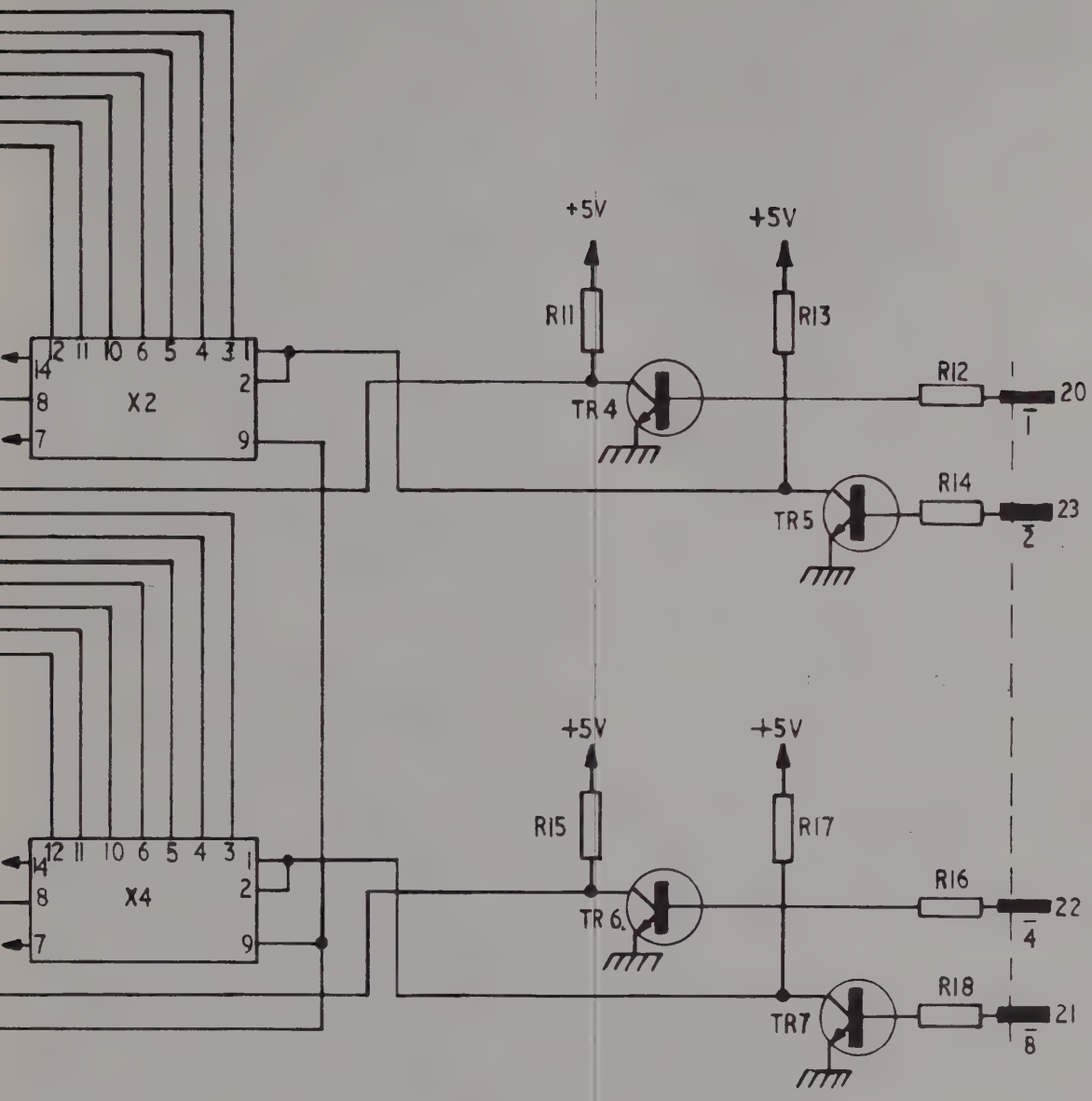


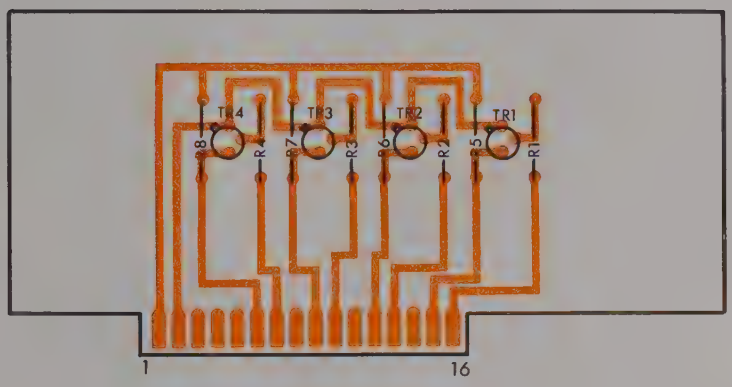
NOTE: CONNECTIONS THUS :- —
REFER TO EDGE CONNECTOR.

PARALLEL B.C.D. INTERFACE

CIRCUIT DIAGRAM

Type 77/900

DRG. NO. E69/27



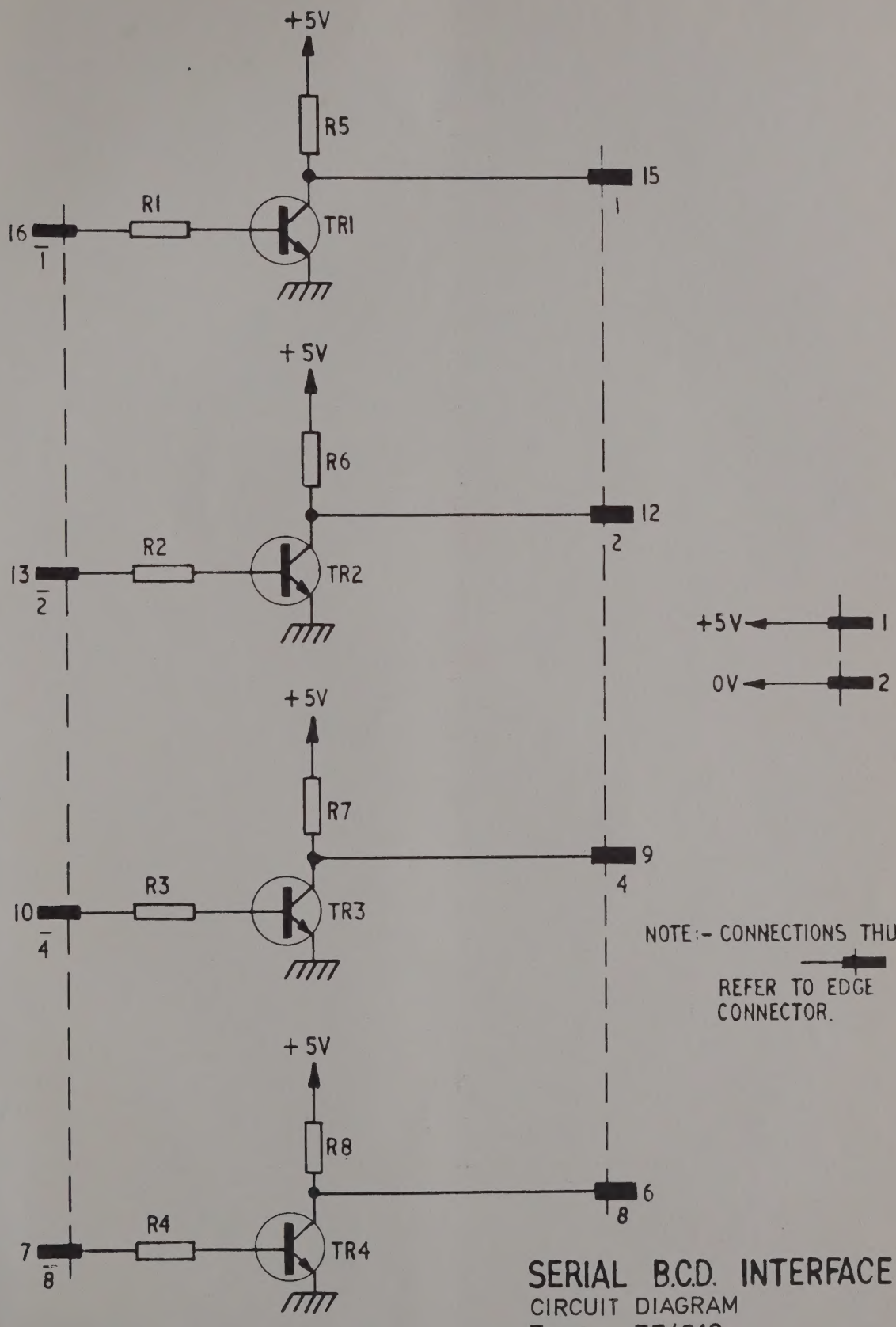
VIEWED FROM NON-COMPONENT SIDE.

SCALE 3/4 FULL SIZE.

SERIAL B.C.D. INTERFACE

TYPE 77/910

BL
77/910



SERIAL B.C.D. INTERFACE

CIRCUIT DIAGRAM

Type 77/910

DRG. NO. E69/33

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